Chinook Populations and Sport Fishing Parameters of Kitimat Arm

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By

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ABSTRACT

Oguss, E. 1982. Chinook Populations and Sport Fishing Parameters of Kitimat Arm. Can. Tech. Rep. Fish. Aquat. Sci. 1117: xiv + 79 p.

A heavily sport fished population of chinook salmon (Oncorhynchus tshawytscha) rearing in the Kitimat Arm/Douglas Channel Area was studied using a mark-recapture method to estimate population size and migration patterns, and a creel census to monitor sport fishing. Floy tags were used to mark 1427 immature chinook, predominately 2_1 age fish. Sport recaptures of tags provided a Petersen estimate of 55,000. Coded wire tags (CWT) and scale pattern data were used to estimate that 2,805 of these fish (5%) were from the Kitimat pilot hatchery; more than half (53%) were from other Canadian hatcheries; the remainder were wild or American hatchery fish. The sport harvest was 6,600 $\pm$ 700, consisting predominately of 2_1 age fish. Mortality due to fishing was estimated to be 9,600 due to a high rate of hooking undersize fish. The sport exploitation rate was 0.17 for the 5 month season. This harvest poses no threat to local populations since few fish of local origin are taken.

CWT data indicate that 98% of chinook smolts produced in the pilot hatchery emigrate from the inlet or perish during their first ocean year. In 1981 CWT recoveries indicated 9.6% recaptured in the local sport fishery, 40.4% in the Canadian commercial fisheries, and 50.0% in the Alaska troll fishery (data from other Alaskan fisheries not available). A map of recapture locations for CWT Kitimat fish and the floy tagged locally rearing population illustrates the more northerly distribution of the former.

Keywords: Kitimat Arm, Douglas Channel, Petersen estimates, commercial fisheries, sport fisheries chinook smolts, Kitimat hatchery, enhancement, mark/recovery.

RÉSUMÉ

Oguss, E. 1982. Chinook Populations and Sport Fishing Parameters of Kitimat Arm. Can. Tech. Rep. Fish. Aquat. Sci. 1117: xiv + 79.

Ce rapport présente une étude d'une population de saumon quinnat (Oncorhynchus tshawytscha) faisant l'object d'une pêche sportive intensive. L'élevage de cette espèce dans la région du bras Kitimat et du chenal Douglas a été étudié à l'aide de la méthode d'étiquetage et de recapture afin d'évaluer l'abondance et les régimes de migration et à l'aide d'une enquête sur la pêche sportive pour contrôler celle-ci. Des étiquettes Floy ont été utilisées pour l'étiquetage de 1,427 saumons quinnats immatures, en majorité des poissons âgés de 2^+ ans. Les recaptures faits au cours de la pêche sportive ont fourni une estimation par la méthode Petersen de 55,000 poissons. À partir des étiquettes métalliques codées (CWT) et des données relevées sur les écailles, on a estimé que 2,805 (5%) de ces poissons provenaient de la piscifacture pilote de Kitimat; plus de la moitié (53%) provenaient d'autres piscifactures

canadiennes et le reset était constitué de poissons sauvages ou élevés dans les piscifactures américaines. L'exploitation sportive s'élevait à 6,600 + 700 poissons, dont la majorité étaient âgés de 2^{+} ans. La mortalité attribuéeà la pêche a été estimée à 9,600, étant donné le taux élevé de prises de poisson de taille inférieure. Le taux d'exploitation de la pêche sportive s'élevait à 0.17 pour la saison de cinq mois. Cette exploitation ne menace aucunement les populations locales car peu de ces poissons sont pris.

Les données tirées des étiquettes métalliques codées démontrent que 98% des saumoneaux quinnats élevés à la piscifacture pilote quittent l'anse ou meurent au cours de la première saison en mer. En 1981, la récupération des étiquettes a démontré un taux de recapture de 9.6% par la pêche sportive locale, 40.4% par la pêche commerciale canadienne et 50% par la pêche à la traîne de l'Alaska (les données des autres pêches de l'Alaska ne sont pas disponibles). Une carte montrant les endroits de recapture des poissons portant des étiquettes CWT provenant de Kitimat et des poissons portant des étiquettes Floy et élevés localement fait voir que le premier groupe est réparti plus au nord.

Mots Cles: Kitimat Arm et Douglas Channel, Petersen estimate, la pêche commerciale, la pêche sportive, rehaussement, étiquetage/ recapture, piscifacture, pilote de Kitimat.

SUMMARY

A study of the chinook salmon population rearing in the Kitimat Arm/Douglas Channel area was conducted using a mark-recapture method to estimate population size and migration patterns, and a creel census to monitor the sport fishery. Floy tags were used to mark 1427 immature chinook, which were predominantly 2_1 age fish. Sport fishing recapture of tags provided a Petersen estimate of 55,000. Coded-wire tags and scale pattern data were used to estimate that 2,805 of these fish (5% of the population) were from the Kitimat hatchery; more than half (53%) of the population were from other Canadian hatcheries, and the remainder were wild or American hatchery fish. (Ninety-eight (98%) of the 151,771 smolts released by the pilot hatchery in May 1979 appear to have emigrated or perished prior to June 1980).

Sport harvesting of the mixed chinook population that reared in the inlet was monitored by creel crensus. From May 10 through September 30, 1980 the sport catch was estimated to be 6,600 $\pm$ 700 chinook, consisting predominately of 2_1 age fish. (The estimated contribution of Kitimat hatchery stocks to this catch is 198 fish.) Mean weight was 3.5 lbs (1.6 kg), mean length 17.9 inches (44.8 cm), and modal length was 16 inches (40 cm). Reported hooking of undersize salmonids was very frequent, estimated at six thousand "shakers" during the study period. Mortality due to fishing was estimated to be 9,600 for the five-month period. The sport exploitation rate on the population was estimated to be 0.17 for the five-month period. In the same time period the commercial net fishery of Area 6 was estimated to have a harvest rate of 0.04 on the 2-year old fish that were rearing in the inlet.

Migration patterns were monitored in 1980 and 1981 by recaptures of Floy and CWT fish; the population Floy tagged in the inlet was found to behave differently from CWT hatchery fish.

Locations of 171 Floy tag recaptures indicated a pattern of random movement throughout the inlet during May and June, with increasing outward movement in July, August and September. Winter tag recaptures indicate that the fish are present both in headwater areas and in the northern and Alaskan troll fisheries. Spring 1981 recaptures were 78% in the inlet headwaters, indicating that a substantial portion of this population reared for 2 years in Kitimat Arm. The last 15 recaptures (July 1981 through January 1982) were all from the Canadian and Alaskan commercial fisheries.

The majority of Kitimat Arm hatchery fish appear to emigrate from inlet headwaters during their first ocean year. CWT data for all Kitimat tag codes in 1981 show 11 tags caught in the local sport fishery (as 2-and 3-year olds), 46 tags in Canadian commercial fisheries and 57 tags in the Alaska troll fishery (other Alaska data not available). These tag recoveries indicate that the majority of Kitimat hatchery fish will be caught in Alaska.

Patterns of sport fishing effort were evaluated from creel census data, and it was concluded that the enjoyment of recreational boating is a more important factor in this fishery than the salmon catch rate or size of fish. The sport harvest of 2-year olds at 1980 levels appears to pose no threat to local stocks. Some management options are discussed.

ACKNOWLEDGEMENTS

The success of this project was made possible by the cooperation and good will of the sport fishermen of the Kitimat Arm area. Their willingness to be interviewed and to allow their catches to be measured provided the data base for this report.

A special thanks is due to the marina and charter operators, who shared their business records and allowed project technicians access to their customers: Don Pearson, Arv Sestrap, Henry Smeets, Ray Hepting and Glenn Mohr.

We also extend thanks to Richard Johnson and the crew of the M.V. Mary Roberta, who diligently pursued our study plan despite difficult conditions and inadequately charted waters.

Many people participated in the field and office work of this project: Beverly McNaughton was chief field technician, assisted by Sterling Shoucair. Bev also assisted with the data analysis and preparation of figures. Diana Day did the majority of the drafting. The typing was cheerfully done by Shirley Flaata.

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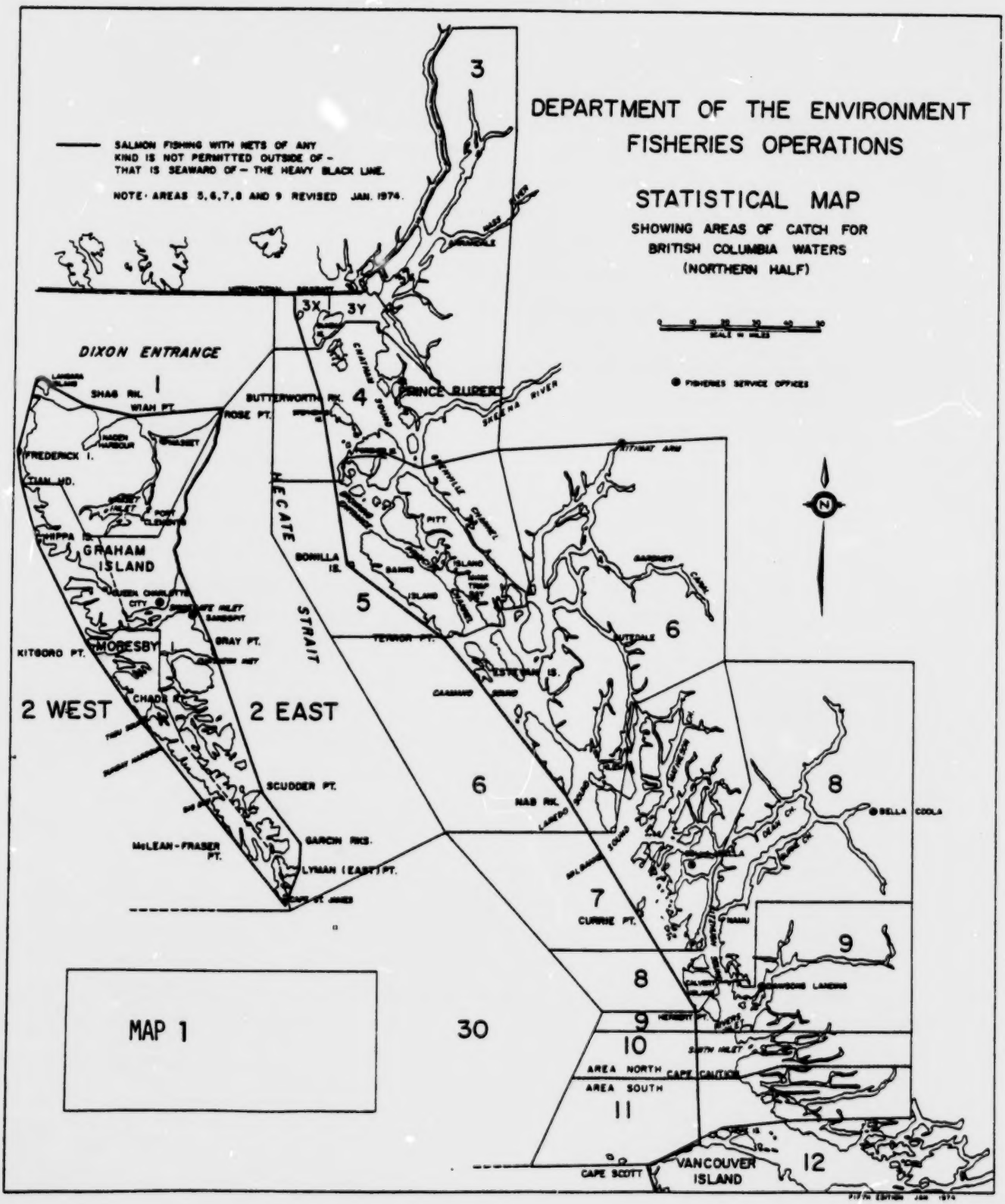
1.0 INTRODUCTION

The management of chinook salmon (Oncorhynchus tshawytscha) in the Kitimat Arm/Douglas Channel area in recent years has been complicated by:

- o a precipitous decline in natural spawning in the largest river system
- o variable output from a new pilot hatchery
- o lack of information about the numbers of 2-and 3-year old chinook rearing in the area or the proportion of them that were of local origin
- o substantial increases in sport fishing in tidal waters

This report presents the results of a mark-recapture program and a creel census that were conducted from May 10 through September 30, 1980, and coded-wire tag (CWT) data on Kitimat hatchery chinook. Marked fish recaptured in the sport fishery provided data for a population estimate, evaluations of stock composition and estimate of exploitation rate. The creel census provided information on the sport fishermen themselves, their methods and fishing locations, their catches, and the sizes and ages of fish caught. Subsequent recaptures of Floy and CWT tags in 1980 and 1981 provided information on the migration patterns and exploitation on both the local rearing and hatchery stocks.

Kitimat Arm is at the head of one of the deepest coastal inlets in B.C. (Map 1). Immature chinook salmon rear in inlet headwaters during the winter and spring, and then gradually move to the outer coast during summer. While some chinook are 'residential', and stay in the vicinity of their native streams throughout two or three repetitions of this annual cycle, the majority migrate (primarily north) along the coast utilizing rearing habitat in many coastal inlets. Therefore, the population of 2-and 3-year old chinook salmon in Kitimat Arm/Douglas Channel consists of local stocks as well as contributions from Gardner Canal, Vancouver Island, the southern B.C. mainland and Washington State. These young fish appear to be highly mobile, with substantial immigration to and emigration from the Kitimat Arm area.


DEPARTMENT OF THE ENVIRONMENT
FISHERIES OPERATIONS
STATISTICAL MAP
SHOWING AREAS OF CATCH FOR
BRITISH COLUMBIA WATERS
(NORTHERN HALF)
SALMON FISHING WITH NETS OF ANY KIND IS NOT PERMITTED OUTSIDE OF - THAT IS SEAWARD OF - THE HEAVY BLACK LINE.
NOTE: AREAS 5, 6, 7, 8 AND 9 REVISED JAN. 1974.
SCALE IN MILES
FISHERIES SERVICE OFFICES
DIXON ENTRANCE
HECATE STRAIT
GRAHAM ISLAND
MORESBY I.
2 WEST
2 EAST
PRINCE RUPERT
SHAG RK.
WIAH PT.
ROSE PT.
BUTTERWORTH RK.
SKEENA RIVER
FREDERICK I.
KITGORO PT.
GRAY PT.
SCUDDER PT.
McLEAN-FRASER PT.
GARCIN RKS.
LYMAN (EAST) PT.
BONILLA IS.
TERROR PT.
NAB RK.
CURRIE PT.
BELLA COOLA
AREA NORTH
AREA SOUTH
CAPE CAUTION
CAPE SCOTT
VANCOUVER ISLAND
MAP 1
30
1
3
3X
3Y
4
5
6
7
8
9
10
11
12

Information on patterns of movement and associated exploitation rates is required in the planning of chinook production at the new Kitimat hatchery facility (scheduled to begin full-scale operations in 1983). These chinook are needed primarily to improve the declining quality of angling in the Kitimat River (one of the most heavily sport-fished rivers in Canada) and to support a rapidly growing salt-water sport fishery in Kitimat Arm/Douglas Channel. No commercial fishery is planned for these chinook, but production levels must be adequate to sustain incidental commercial catches in Alaska and Canada.

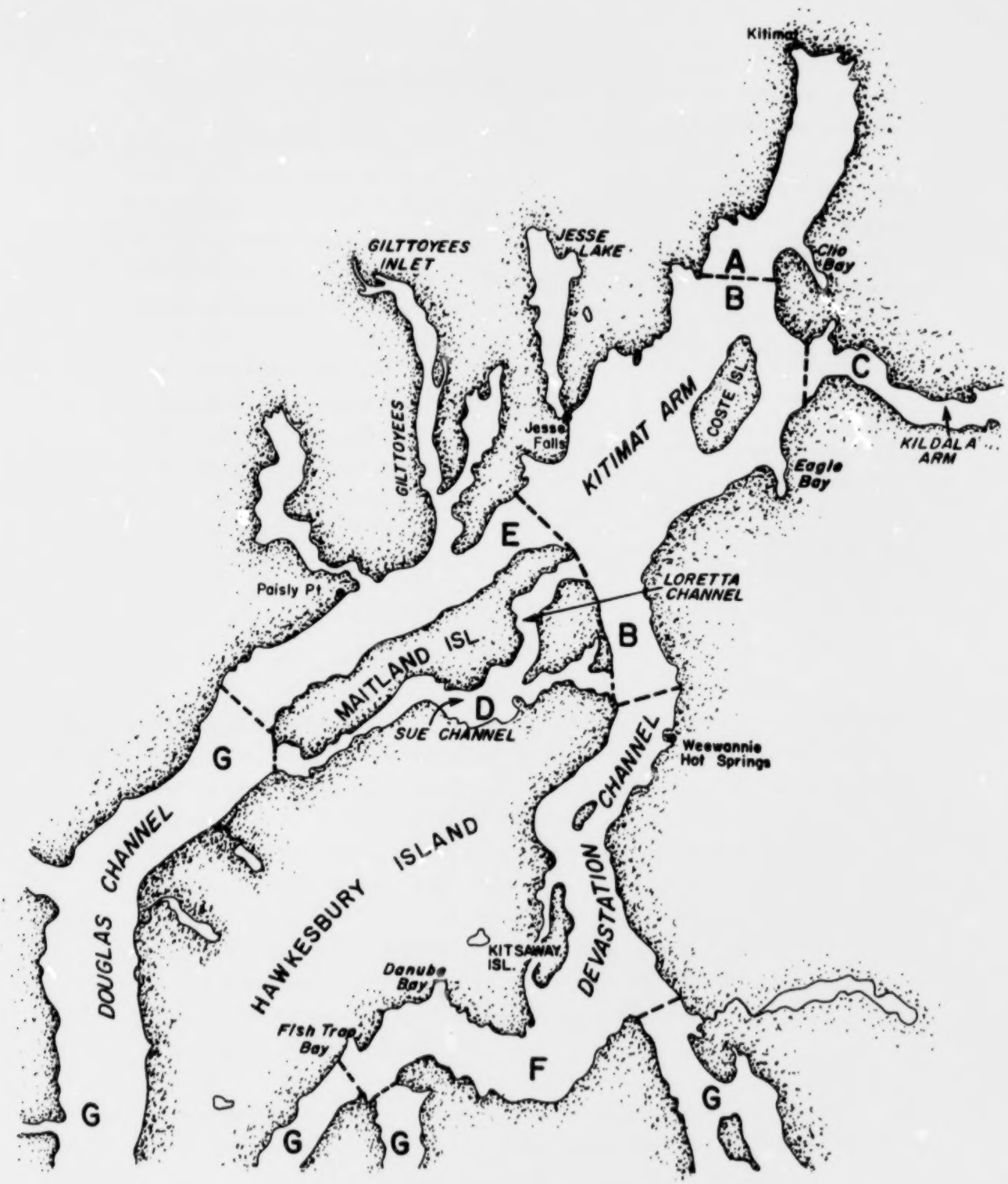
2.0 THE STUDY AREA

Kitimat Arm (Map 2) is the head of a deep coastal fjord located 715 km northwest of Vancouver, on the B.C. mainland. It is connected to Hecate Strait and the Pacific Ocean through a number of deep narrow channels - principally Douglas Channel. Except for the town of Kitimat (pop. 15,000) the area is largely unpopulated and undeveloped. Kitimat is the site of the Alcan aluminum smelter and also of the Eurocan pulp mill.

Chinook salmon (Oncorhynchus tshawytscha) are one of the primary natural resources of the area. The Kitimat River is the main spawning stream for chinook, and a pilot hatchery on the river opened in 1978 to enhance chinook production. Other significant chinook stocks are found in the Dala, Kildala and Bish. These local stocks or portions thereof use the Kitimat Arm area for rearing during their ocean years, and the area is also used by immature chinook originating in many other B.C. streams and from as far away as Washington and Oregon.

Although the study area is vast, the rearing habitat available in it appears to be limited and productivity may be low. The shoreline consists primarily of precipitous rock walls. The few small estuaries and bays that provide some surface water drainage and/or shallow waters are the favoured fishing spots and appear to have higher densities of fish than other areas. The study area probably has the low-nutrient surface drainage that is typical of the central coast of B.C. (Stockner, 1981). Atmospheric Environment Service records show average precipitation for Kitimat to be 2,826 mm per year, with an average of only 1,065 hours of sunshine. Low nutrient levels and limited sunlight may combine to limit primary production in inlet waters relative to some of the southern B.C. coastal inlets. It is recommended that an investigation into the carrying capacity of the inlet be done in connection with the planning for production at the new Kitimat hatchery.

The rapidly expanding sports fishery of Kitimat currently supports 6 marinas and public launching areas in Kitimat Arm, 6 local charter services, 3 out-of-town



MAP 2: Kitimat Arm Study Area, Showing Subareas.

charter boat services, 2 fishing camps and 2 remote logging camps that do some recreational fishing in the study area.

The MK Bay Marina was the site of the majority of the creel census interviews and is the largest of the sport fishing facilities in the area. It is located approximately 13 km from Kitimat on the east side of Kitimat Arm. In 1980, the marina provided moorage for 165 boats averaging 24' in length. It has a fuel dock and fishing supply store. Interviews were also conducted at the other marinas and launching sites throughout the study period.

Although the study area is very large, fishing effort tended to concentrate in several well known areas. Early in the season, Jesse Falls and Coste Island were favored spots. As the salmon moved seaward the sport fishermen followed, venturing to Weewanie Hot Springs, Kitsaway Island, Danube Bay, Fishtrap Bay and even further.

3.0 STUDY DESIGN & METHODOLOGY

3.1 Population Estimation

The highly mobile chinook population in the study area, with unknown contributions of rearing juveniles from other areas, provided a unique challenge to population estimation methodology. The initial method chosen was the Seber-Jolly open population model (Seber, 1973, Ricker, 1975), augmented with 8 days of test fishing (seine) to refine estimates of immigration and emigration. The Seber-Jolly method requires 4 fishing episodes and provides an estimate of the dynamics of fluctuation in an open population. However, the number of tagged fish needed to get similarly reliable estimates is approximately 3 times the number needed for simple Petersen estimates (Gilbert, 1973). Experience in the study area showed that adequate numbers of juveniles could not be captured for tagging without violating the requirement of covering the entire study area. Therefore, a simple Petersen estimate was made, using the sport catch as the recapture sample.

3.1.1 Floy Tagging Schedule

The tagging program was initiated on the 13th of May 1980. Several sets were made with a herring seine in Kitimat Arm to examine the performance of the net and tagging equipment. After completing a set during high velocity of tidal currents, severe tears were found in the herring seine net. To prevent further damage, the net was replaced by a salmon seine net with a herring bunt-end. Tagging operations were then resumed on the 19th of May with a schedule designed to fit the Seber-Jolly method of estimating open populations. The schedule called for 3 periods of 5 days each, at two-week intervals, with a fourth 5-day fishing effort devoted to recapture only. In addition, a test fishing period of eight days was scheduled to estimate the dilution rate of tags due to immigration and emigration.

After the second period of tagging, analysis of the fishing success showed that catch rates were too low to provide statistically valid estimates using the Seber-

Jolly method, and therefore the program was modified. Priority was given first to making a valid estimate of the chinook population based on a simpler Petersen model, and second on maximizing the number of tagged fish. Subsequent tagging operations were conducted for 2 periods of 8 days each, at two-week intervals, thus combining additional tagging with the recapture and test fishing effort.

3.1.2 Tagging Locations

During each period of the tagging program, several sets were made in each of the subareas (A-G) shown in Map 2, thereby monitoring the entire study area. The location of the sets within the subareas was dependent upon the direction and velocity of the tidal currents, coastal shoreline, water depth, bottom terrain, sonar readouts and previous seine and sport fishing success. Table 3-1 shows a summary of tagging operations by subarea.

TABLE 3-1: Tagging Effort and Releases of Tagged Fish, by Subarea.

Subarea	May 13-23	May 26-30	June 6-13	June 21-28	Totals	CPUE
A seine sets	6		5		11	3.0
fish tagged	12		21		33	
B seine sets	21	18	14	9	62	14.3
fish tagged	162	237	391	94	884	
C seine sets			2		2	3.5
fish tagged			7		7	
D seine sets	5		1	8	14	2.0
fish tagged	4		2	22	28	
E seine sets	3	2		21	26	6.7
fish tagged	56	0		117	173	
F seine sets	3	18	12	11	44	7.5
fish tagged	6	175	67	81	329	
Total seine sets	38	38	34	49	159	9.1
Total fish tagged	240	412	468	314	1454	

3.1.3 Tagging Equipment

The fishing vessel MV Mary Roberta, owned by Pravda Holdings, Nanaimo (Mr. Richard Johnson) was chartered for the tagging operations. This vessel is a 58 foot purse seiner with a 16 foot powered skiff and a crew of four which assisted in the tagging operations. When temporary engine problems occurred on the MV Mary Roberta, the MV Sanderling I, a 65 foot purse seiner, was chartered for four days (June 21-24) of the tagging program. The MV Sanderling I used the same net and other tagging equipment that had been used on the MV Mary Roberta.

The herring seine net originally planned to capture the juvenile chinook salmon was approximately 439 m (240 fathoms) in length, 81 m (45 fathoms) deep with a mesh size of 2.5 cm (1"). Due to strong tidal currents in the study area the herring net was replaced with a salmon seine net approximately 403 m (220 fathoms) in length, 33 m (18 fathoms) deep, an 8 cm (3") mesh size and 3.6 kg (8 lb) lead line. Attached to the salmon net was a section of knotless herring seine net approximately 37 m (20 fathoms) in length and 33 m (18 fathoms) in depth. This net was used to hold the fish before tagging. The mesh size (2.5 cm) and texture of the net provided minimal scale loss, prevented gill damage and enabled the project technicians to retain and record other fish species in the study area. This combination of salmon/herring seine net was used on both chartered vessels.

3.1.4 Tagging Procedure

The seine net, with the aid of a powered skiff, was hauled from the drum and set for approximately 15-20 minutes. Depending on the water depth, bottom terrain, tidal currents and coastal shoreline of the study area, the forward purse line was positioned on the shore for a beach set or close to shore (attached to the powered skiff) for an open set. When pursing was completed and the purse rings and lead lines were aboard, the herring net was pulled to the lee side of the boat and hauled up by the crew until a holding pond was formed. The cork line of the herring net was hoisted by a winch to increase the pool width and provide easy

access to the salmon. This method prevented the net from folding against itself, thereby minimizing scale loss and enabling quick identification of the fish species.

A dip net constructed of soft nylon mesh (again to prevent significant scale loss) was used to remove the juvenile chinook salmon. Each fish was immediately put onto the tagging table and tagged with an orange anchor tag (Floy style FD-68B) supplied by the Department of Fisheries and Oceans. The Floy tag number and length measurement were recorded and scale samples taken for each chinook salmon. The salmon was then returned to the water and observed until out of sight. This tagging procedure took approximately 10-15 seconds with virtually no mortalities witnessed. Adult chinook salmon were also tagged using the same procedure except a Petersen disc tag was inserted instead of an anchor tag. The numbers of adipose-fin clipped fish (i.e. CWT) and the identification numbers of recaptured Floy tagged fish were recorded for each set. The remaining species in the net were identified, counted, recorded and released.

3.1.5 Differences Between The Tagged and Recaptured Populations

Since sport catches were used as the recapture technique in this experiment, it was important to determine the degree to which the sport fishery was harvesting the same fish as the seine boat. The length frequency distribution of fish caught and tagged by the seine was compared with the length frequency distribution of sport catches during May and June. These are shown in Figure 3-1.

It is evident that the seine caught a substantial number of fish under the 12 inch (30 cm) legal limit for sport catches, and also that the seine caught fewer large fish than the sport fishermen.

Therefore, the number of tags deployed has been adjusted to delete the 62 tags that were put on fish too small to be accessible to the sport fishery. Population estimates based on the mark-recapture results are taken to apply primarily to the 2_1 and 3_2 age classes that dominated the tagged population.

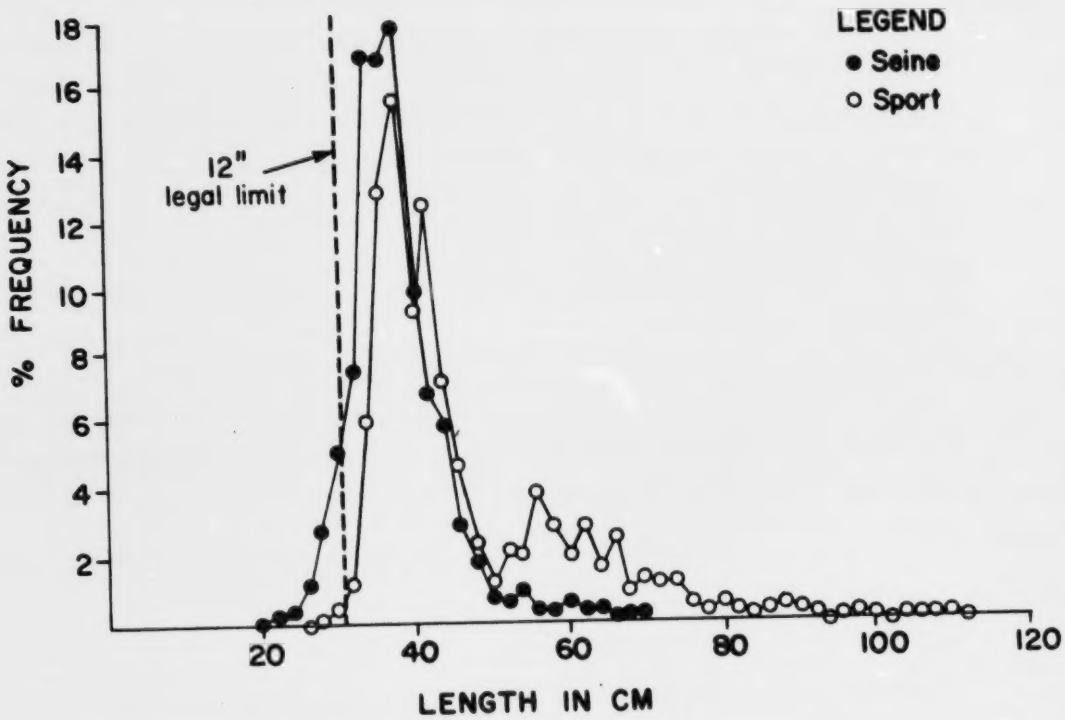


FIGURE 3-1: Length Frequency Distribution of Seine Tagged Chinook Compared with May and June Sport Catches.

3.1.6 Coded-Wire Tag Recoveries

Many of the chinook using the Kitimat Arm area have been marked as smolts with a coded-wire tag (CWT) implanted in the nose. These fish are identifiable to the informed observer by having their adipose-fin removed. The commercial catch from Area 6 was scanned for adipose clipped fish at the fish processing plants. Sport recoveries of CWT fish depend upon the awareness of the sport fishermen in noticing the missing adipose fin, and their cooperation in handing in the head of the tagged fish at a head recovery depot. One head recovery depot is located at MK Bay.

In the course of conducting the creel census, project technicians were in a position to intercept many adipose-clipped fish in the sports landings, to evaluate the awareness of the fishermen concerning the CWT program, and to ensure a higher than usual recovery of tags from the sport fishery. The excellent rate of recovery of CWT information from the sport fishery contributed to the analysis of stock composition for the area. Observations of tag awareness have been summarized in the companion Data Report.

3.2 Creel Census

The creel census consisted of a brief dockside interview, with emphasis on the details of the current day's catch and fishing effort. A minimum coverage of 34% of all angler-days was achieved on a monthly basis throughout the 5-month study period (Table 3-2). Data from the creel census were used to estimate total chinook catch and fishing effort. Many factors in fishing success, such as baits and mobility, were evaluated in terms of catch per unit effort and, in some cases, the sizes of the fish caught. Although some sociological factors such as the residence of the fishermen were covered, the emphasis of the creel census was on the dynamics of fishing and the catch. The broad economic and social aspects of the sport fishery, which were addressed in the 1978 creel census (Masse, unpublished), were not included in the 1980 project.

TABLE 3-2: Fishing Effort & Percent Coverage.

	May	June	July	Aug.	Sept.
Fishing Boats Interviewed	118	225	230	406	262
% Boats Not Salmon Fishing	0.8	5.2	8.5	12.1	24.1
Fishermen Interviewed	293	617	675	1,234	708
Average Fishermen per Boat	2.48	2.74	2.93	3.04	2.70
Creel Census (% coverage)	34.5	36.9	36.5	41.7	46.9
Chinook Caught by Interviewed Fishermen	477	771	664	559	211

3.2.1 The Interview

Data from the interview (Figure 3-2) included: location of the day's fishing, duration of fishing effort, type of bait and/or artificial lures used, length and weight of the chinook salmon caught, number of shakers (i.e. undersize fish) released, and for the previous six calendar days, the frequency of fishing and the number of species caught. The boat length and type of engine mounting (i.e. inboard or outboard) were also recorded as well as the total number of fishermen and total catch on the boat. Adipose-fin clipped and Floy tagged fish were noted along with their weight and length measurements for growth rate estimates. Scale samples were taken whenever possible throughout the monitoring program, but many of the fish had been scaled before the interview.

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CREEL CENSUS

Kitimat Arm Chinook Project

Date _____ Time _____ Interview Location _____

Base _____ Kitimat _____ Fishing Camp _____ Boat

Residence _____Kitimat/Terrace _____ B.C. _____Canada _____ Foreign

Today's fishing effort:

Location _____ Sub Area _____

Duration _____ hours Number of Lines _____

Bait _____

Gear _____

Boat: Length _____ Motor _____ Owned _____

Today's Catch:

Species	Length	Weight	Scale Number	Tags

Shakers: Chinook _____ Coho _____ Other _____

Tag Awareness _____

Frequency of fishing during previous week: _____ days

Catch during previous week:

Chinook: under 5 lbs _____ over 5 lbs _____

Other salmon _____

FIGURE 3-2 : Creel Census Interview Form.

3.2.2 Coverage of the Kitimat Arm Area

Sport fishermen were interviewed from May 10th to September 31st at MK Bay Marina, the Kitimat Yacht Club and Alcan Beach. Interviews were conducted from early afternoon to dusk (approximately 1300 - 2000 hours) seven days a week. During weekends and holidays sport catches were monitored at all three locations. During weekdays, when the number of sport fishing boats decreased, interviews were conducted primarily at the largest marina, MK Bay. Fishermen using the other moorages were often interviewed at MK Bay since it provided the primary fueling station and fishing supply store. The number of sport fishing boats in the channel from Alcan Beach and Kitimat Yacht Club was estimated by counting the number of boat trailers and utilized moorage spaces respectively. Sport fishing boats leaving and returning from the Minette Bay Marina were easily viewed from MK Bay. For each day of the monitoring program, a record was made of the estimated total number of boats out, including an estimate of those engaged in activities other than salmon fishing - crabbing, pleasure trips, etc.

3.2.3 Coverage of Fishing Camps and Charters

Catch statistics and tag data from the sport fishing camps and out of town charter boats in the study area were based on the records made by the operators of these businesses. Personal contact was established in the early part of the study when the MV Mary Roberta was tagging in the areas used by the fishing camps and charters. On August 2nd, a 25-foot powerboat was chartered for a two-day period in order to revisit the sport fishing operations in the outer part of Area 6. Monthly estimates of the sport catch were obtained from the Kemano Bay Marina, Collins Bay logging camp and Hartley Bay. Catches from the Bishop Bay logging camp (Crown Zellerbach) were estimated from information obtained from employees who were interviewed at MK Bay. Sport fishermen fishing in the study area were interviewed during the two day charter and tag recovery data collected at all the fishing locations. For the remaining days in August and the month of September, catches were estimated using the

records of the fishing camps and charters and information obtained from fishermen returning from the study area.

3.3 Data Analysis and Statistics

3.3.1 Confidence Intervals for Estimates of Total Catch

Estimates of catch were calculated by taking the observed catches of creel census interviewed fishermen and multiplying by 1/C, where C = the proportion of sport landings covered by creel census interviews. For example, if the interviewed fishermen caught 159 chinook during a period when coverage was estimated to be 35%, the estimate of chinook catch would be 159/0.35 = 454. Since there was no statistical way to put confidence limits on the estimates of coverage, this method was considered to be preferable to methods that would stratify the data and require using the daily estimates of coverage.

The procedure above does not provide confidence intervals on the estimates. Computation of confidence intervals is complicated by the fact that individual catches constitute discrete (rather than continuous) data and are not normally distributed. The problem was approached by using the daily CPUE's (computed as the total catch of interviewed fishermen divided by the number of interviewed fishermen, excluding interviews where the interviewee claimed not to be fishing). These CPUE's then constituted a continuous data set which reasonably approximated a normal distribution. A mean CPUE for the week was then determined and one standard deviation given as the confidence intervals on these means. The confidence intervals were then multiplied by the estimated effort for the week to give maximum and minimum estimates for the catch.

It should be noted that these confidence limits describe the precision of the CPUE's observed, but do not reflect the accuracy of the estimates of total effort.

In the detailed discussion of the creel census data the catches are often stratified (by subarea, by bait used, etc.) and estimates calculated for the catch attributable to each sector. These have been done on a monthly basis, using

observed catches for the month expanded by the percent coverage, for the month, as described in the first paragraph above. Therefore, they are subject to rounding error - i.e. the sum of the data stratified in one manner does not exactly equal the sum if it is stratified in a different manner. All of these deviations are within the confidence intervals of the overall catch. Estimates of total catch for any given sector should be taken as approximations only.

3.3.2 Growth Rates

Determination of the juvenile chinook growth rate was calculated from length measurements taken during the tagging operation and their subsequent recapture from the sport fishery. During the 1981 season, 101 tags were returned by the sport fishery, of which length measurements at recapture were recorded for 35. Relative rates of increase were calculated as $(L_2 - L_1) / L_1$, where: L_2 = length at recapture; and L_1 = length at tagging. Instantaneous rates of increase were calculated as $(\text{Log } L_2 - \text{Log } L_1)$ using natural (base e) logarithms.

3.3.3 Age & Life History

Scales were taken from all tagged fish and from approximately 20% of sport caught fish landed by interviewed fishermen. Scale smears were found to be the only practical method of sampling the seine caught fish since speed of handling was essential and weather conditions were often poor. Scales were subsequently remounted individually for reading. Scale reading was performed by Department of Fisheries and Oceans personnel under the supervision of the scientific authority.

The notation used in this report to describe the age and life history from scale reading is the Gilbert-Rich method. The first digit is the age of the fish including the first winter prior to emergence. Subtracting this digit from the calendar year of catch gives the brood year. The second digit, shown as a subscript, is the number of winters spent in fresh water, including the first winter prior to emergence.

Thus a 2_1 chinook caught in 1980 is from an egg deposited in 1978. It emerged, smolted and left fresh water in 1979 and grew its first winter annulus in salt water. By the European method of notation, this would be a 0.1 fish. Its 'ocean age' is 1.

A 3_2 fish also has an 'ocean age' of 1, but has spent 2 winters in fresh water. It has one fresh water winter annulus and one salt water winter annulus. It is from the 1977 brood year. By the European method it would be noted as 1.1.

In addition to identifying age and life history, the scale readers were able to identify a distinctive pattern on the scales of hatchery fish (Yvonne Yole, personal communication). Hatchery fish were found to have larger and 'better' annuli, probably due to feeding, which made their scales very different from the wild populations of the central coast. When reference is made in this report to hatchery fish identified by scale pattern, it is the identifications made by the DFO scale lab that are being used. Although some attempt was made to identify Kitimat fish distinct from other Canadian hatcheries, the lack of known 'feeder' samples for comparison and the similarity of culture methods have made it impossible at this time to make this distinction (Yvonne Yole, pers. comm.).

Coded-wire tag data from Area 6 was provided by DFO (see Section 3.1.6).

4.0 POPULATION ESTIMATES & MIGRATION

Accurate estimates of the juvenile chinook populations in the study area were complicated by the high mobility of the fish within the area, their patchy distribution, and possible high rates of immigration and emigration. Although it had been originally planned to estimate the population using seine-caught marked fish and seine recaptures, the catch per set of the juveniles was very low (mean = 9.1) by this method; only 2 of the 1,454 marked fish were recaptured by seine one or more days after marking. However, the 171 sport recaptures, along with creel census data on the sport fishery and the coded-wire tagging information, constitute a valuable data set from which much information can be gleaned.

Several methods of estimating the population size were pursued:1) the standard Petersen method (Ricker, 1975) to provide the best point estimate of population size; 2) Ketchen estimates (Ketchen, 1953) were calculated to estimate immigration and emigration rates; 3) an examination of the dilution rate of tags. The patterns and timing of migration were examined based on recapture data. Finally ,the stock origins and composition were examined using coded wire tagging data and scale reading data.

4.1 Population Estimates

4.1.1 Petersen Method

The Petersen method assumes that the population is 'closed' (i.e. no immigration or emigration) and that mortality is not a factor during the sampling period. The Kitimat Arm - Douglas Channel juvenile chinook population is an open one and experiences significant fishing mortality during the season. However, the Petersen estimates were calculated as a familiar starting point and to provide comparison with the other methods that follow.

The Chapman adjustment of the Petersen Estimate (Seber, 1973) was used:

$$N = \frac{(M + 1)(C + 1)}{R + 1} - 1$$

where N = estimated number of fish at the start of the recapture period
M = number tagged
C = number sampled for marks
R = number of recaptured marks in the sample

Although many tags were recaptured by fishermen who were not interviewed in the creel census, only tags recaptured by interviewed fishermen and total catches by interviewed fishermen were used. This was necessary in order to calculate C with the greatest accuracy.

The quantity M, the initial number of tags, had to be adjusted to account for tag loss, tags recaptured prior to June 26, tags put on fish less than 12" (i.e. not accessible to sport fishery) and several misidentified (not chinook) fish. The latter category were identified by scale reading. The rate of initial tag loss (i.e. due to tagging mortality and shedding of tags within the first month after tagging) was not measured; the 10% figure is borrowed from a juvenile tagging program in Puget Sound (Michael Eames, personal communication).

Total tags deployed, May 13 - June 26	1454
10% tag loss	-145
Tags on fish less than 12"	-62
Tags recaptured prior to June 26	-25
Non-chinook tagged	-27
M = number of tags as of June 26	1195

To determine the effect of emmigration on the Petersen estimate, the calculation of the population size on June 26 was done twice, first using half the data set (June 26 through August 3) and then using the entire data set (June 26 through September 7).

1. Creel census data from June 26 to August 3:
   M = 1195
   C = 926 fish caught by interviewed fishermen

R = 19 tags recaptured by interviewed fishermen

$$N = \frac{(1195 + 1)(926 + 1)}{(19 + 1)} - 1 = 55,434$$

95% Confidence Limits:
Upper: 91,212
Lower: 37,348

2. Creel census data from June 26 to September 7:

M = 1195

C = 1463 fish caught by interviewed fishermen

R = 31 tags recaptured by interviewed fishermen

$$N = \frac{(1195 + 1)(1463 + 1)}{(31 + 1)} - 1 = 54,716$$

95% Confidence Limits:
Upper: 80,197
Lower: 39,787

It was expected that these two calculations would differ more than they do, since Floy tag recapture locations show the fish to be emigrating from the study area during August. The consistency between the two estimates suggests that the emigration rate is proportional to the drop in catch per unit effort - i.e. if the catch rate had not dropped in August, the quantity C in the second calculation would have been much higher, and the resulting N would have increased.

4.1.2 Ketchen Method

The model developed by Ketchen (1953) (Ricker, 1975) applies the Leslie model (i.e. CPUE vs cumulative catch) plus tagging data in order to estimate immigration and emigration in open populations. It assumes that immigration and emigration occur at constant rates, proportional to the number of fish present in the study area. The method compares the observed attrition of tagged individuals with the declining CPUE of untagged fish (Figure 4-1).

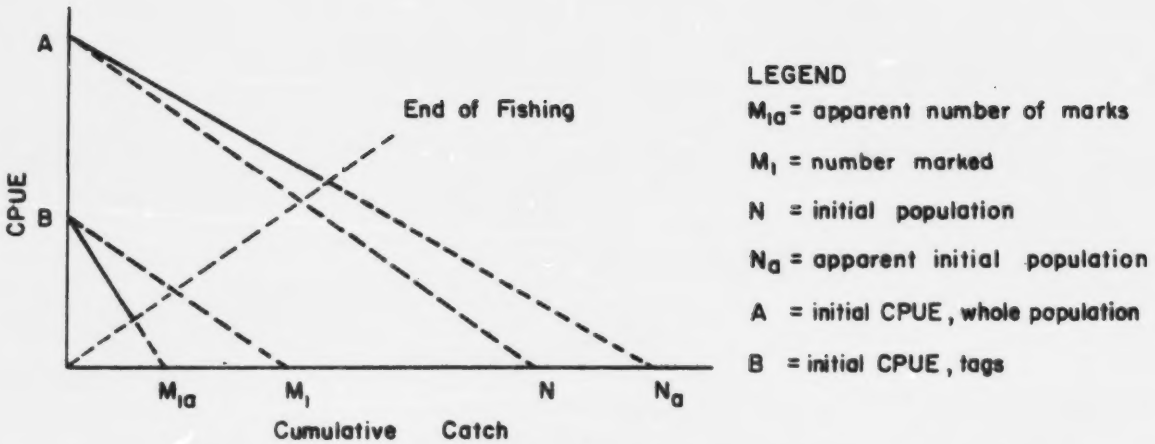


FIGURE 4-1: Diagram showing relationship between Leslie estimates of the whole population (above) and the marked population (below). Modified from Ketchen 1953.

The initial population is estimated by:

$$N = \frac{Na\,(F + y - z)}{F}$$

where Na = "apparent" initial population

F = instantaneous fishing rate = $\frac{M_{1a}}{M_1}(F + y)$

y = proportion of N immigrating during the study period

z = proportion of N emigrating during the study period

In Figure 4-2 creel census data from the Kitimat Arm - Douglas Channel sport fishery has been graphed, showing the declining sport catch per angler-day over cumulative catch, for both marked and unmarked populations. As calculated in the preceding section, there were 1,195 tags at large at the start of the program, June 26. Figures were calculated on a weekly basis, in order to average out the effect of greater fishing effort during weekend periods. The period of time during which immigration and emigration are estimated is June 26 through September 7. The remainder of September is not included due to the absence of tag recaptures after September 7. The lines shown were calculated by the method of linear least squares.

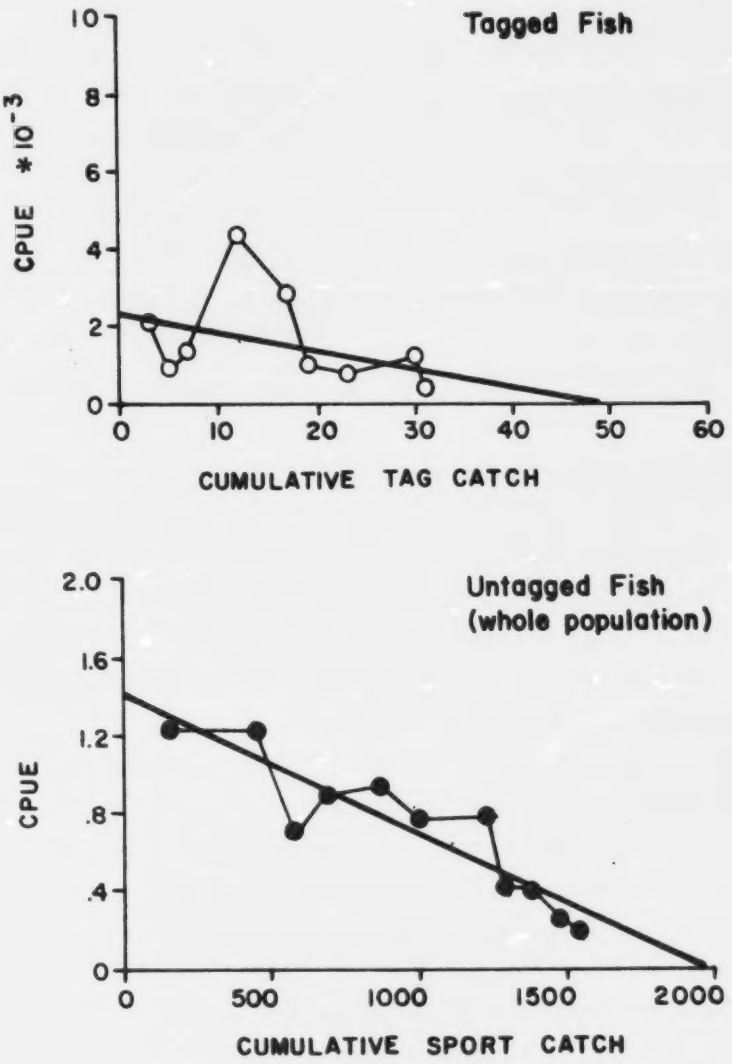


FIGURE 4.2: Catch per Fisherman-Day of Tagged and Untagged Fish, Used in Ketchen analysis. (See text)

Slope B (tagged population) = $\frac{(F + y)}{f}$ = -0.000472 f = total effort

M_{1a} = 50 fish

Slope A (untagged population) = $\frac{(F + y - z)}{f}$ = -0.000717

Na = 1,977 fish

Total sport fishing effort during this time was 2,314 angler-days. Therefore the initial population estimate, as of June 26, is:

$$N = \frac{Na\ (F + y - z)}{F} = 71,726 \quad \text{(late June)}$$

and migration rates for the period June 26 through September 7 are:

Emigration rate = 1.045 Total emigration = 74,987
Immigration rate = 0.568 Total immigration = 40,734

Thus the total number of fish using the study area during the period of late June through early September was 71,726 + 40,734 = 112,460; and the number departing the study area was 74,987, leaving a population of 37,472 at the end. These figures, along with the picture of changing densities in the different subareas during the season, fit reasonably well with the general impressions reported by fishermen in the area concerning chinook catch rates.

It should be noted that the Ketchen method assumes a constant catchability. Peterman and Steer (1981) have shown that catchability of salmon in the sport fishery is a density dependent function, with higher catchabilities observed at low abundances. Therefore, the declining CPUE observed in the Kitimat Arm study area may underestimate the actual decline of abundance. This would also produce an overestimate of immigration during the season.

4.1.3 Rate of Dilution of Marks

In an open population one would expect that the combined effects of immigration and emigration could be monitored by observing the dilution rate of the tags -i.e. that over time the proportion of the population that was tagged would decrease as emigrating tagged fish were replaced by immigrating untagged fish.

Figure 4-3 shows the proportion of marked to unmarked fish over the 12 week period following the end of tagging operations. Only creel census data are shown here, but the same general picture is apparent when total sport recovered tags and estimated total sport catch are used.

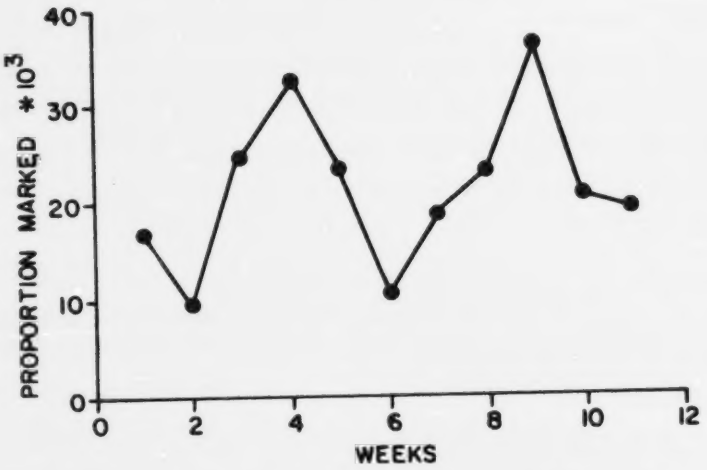


FIGURE 4-3: Proportion of marked fish in observed catch.

It is concluded that the random variation in the number of tags recaptured each week surpasses the effect of immigration and emigration, and therefore that the proportion of the population tagged was not adequate to measure these migration parameters with any accuracy.

4.1.4 Conclusions

The Petersen estimate of 55 thousand chinook salmon for late June appears to be valid despite immigration and emigration. The Ketchen estimate of 72 thousand for the same time is within the confidence limits of the Petersen estimate and is judged to be somewhat less reliable since the coefficient of correlation of tag CPUE against cummulative tag catch is only 0.405.

Therefore, we estimate the population in late June at 55,000 (95% Confidence Interval, 80,000 and 40,000). This estimate applies primarily to 2_1 and 3_2 age chinook that were greater than or equal to 12 inches, since smaller fish were not recaptured in the sport fishery and larger age classes were not tagged in sufficient numbers. Catch/effort data suggest that the population was declining throughout the study period and probably had peaked before early May. The population may have been as much as 50% greater in early May than it was in late June (i.e. perhaps 70 to 80 thousand), and by late September it had declined substantially. The Ketchen estimate suggests 37 thousand for September 7, and the catch/effort data (Figure 4-2) indicate an 80% decrease (i.e. 11 thousand) by late September.

The number of marks deployed was not sufficient to develop reliable estimates of immigration or emigration rates.

4.2 Migration Movements & Timing

The 2-and 3-year old chinook that constitute the main sport catch in the Kitimat Arm area (the majority of which are not of local origin) appear to have an annual cycle of utilization of the inner coastal area. Abundance during the winter (October through March) is very low, as indicated by sport catches in the inlet waters (Figure 5-2). There is a sharp increase in catch and CPUE in April, with CPUE peaking in May and monthly catch peaking in June (Table 5-2). The fish appear to enter the coastal inlets during April and May and to roam about these inner waters during June and July, congregating in suitable rearing areas. In August, when sport fishing effort is at its peak, the chinook population has

declined in the headwaters of the inlet, and fishermen must travel to Ursula Channel, Verney Passage and McKay Reach to increase their success. August and September creel census data show an increasing proportion of recreational boating that is not directed to salmon fishing. September and October sport catches are low.

Prior to this study, it was not known whether the decline in abundance in the upper inlet was due to emigration or due to exploitation by the sport fishery. It is now clear that the size of the sport catch is not great enough to account for the decline in the CPUE and that migration is the major factor in reducing catches in the inlet headwaters.

4.2.1 Floy Tag Recaptures

The location of recapture has been drafted for most of the 171 reported Floy tags returned from June, 1980 through January 1982 (Figures 4-4 A-G). (Several tags were returned with no location data.) Numbers by recapture symbols indicate scale reading results (see 3.3.3) based on scales taken during tagging - i.e. May and June 1980. The recapture results are discussed in order of the month of recapture.

A detailed listing of the data is available in the companion Data Report, which also contains figures of the same data separated by the location and month of the initial marking. The figures show clearly that the fish do not 'school' for long periods - i.e. fish marked at one location are recaptured is different areas. Fish marked in May do not appear to behave differently from those marked in June.

4.2.2 Summary of Floy Tag Migration Patterns

The Floy tag recapture data shows a general pattern of wide-ranging use of the entire Kitimat Arm/Douglas Channel area (except for Kildala Arm) during June and July with obvious increases in outward migration during July and August, and relatively little use of inlet waters by September. This corresponds well with the sport CPUE data. Recapture data for October to February 1980 indicate that the majority of the recaptured fish had overwintered in the inlet headwaters.

FIGURE 4.4-A: Floy Tag Recapture Locations of June 1980 (•) and June 1981 (*).

FIGURE 4-4B: Floy Tag Recapture Locations for the Months of July 1980 (•) and July 1981 (*).

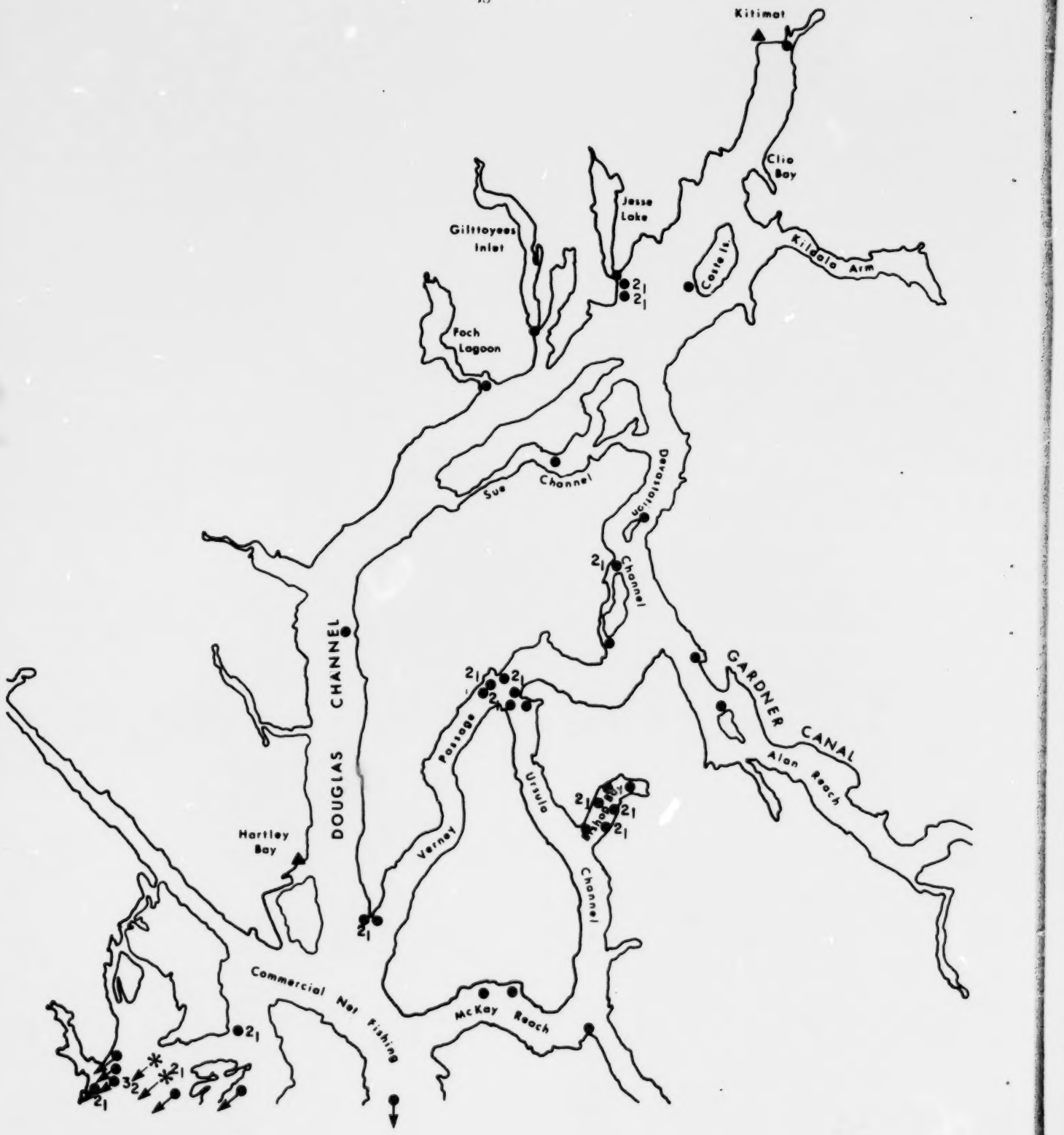


FIGURE 4-4C: Floy Tag Recapture Locations for the Months of August 1980 (•) and August 1981 (*).

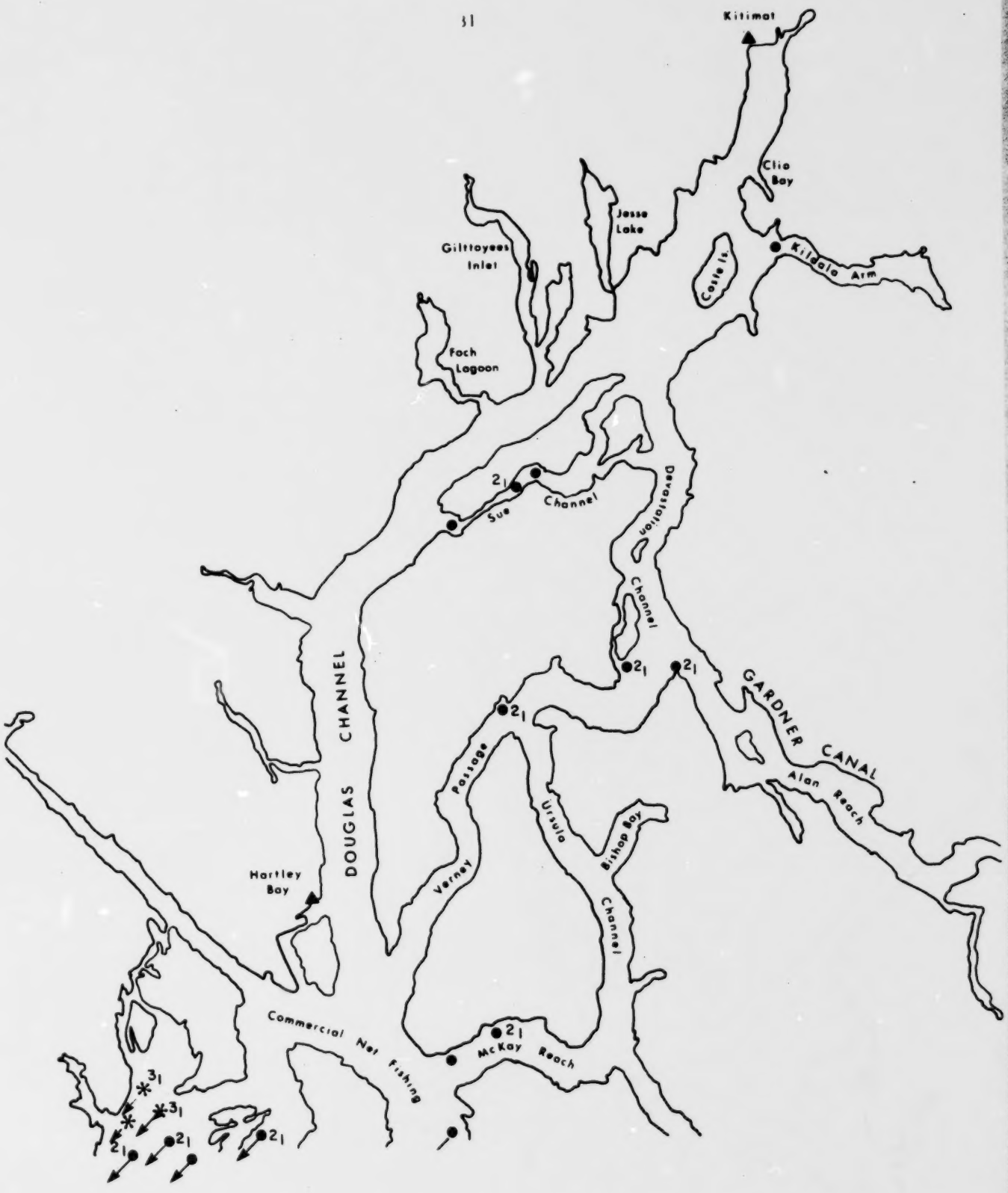


FIGURE 4-4D: Floy Tag Recapture Locations for the Months of September 1980 (•) and September 1981 (*).

FIGURE 4-4E: Floy Tag Recaptures October 1980 - February 1981 (•).
October 1981 - February 1982 (*).

FIGURE 4-4F: Floy Tag Recaptures March - April 1981.

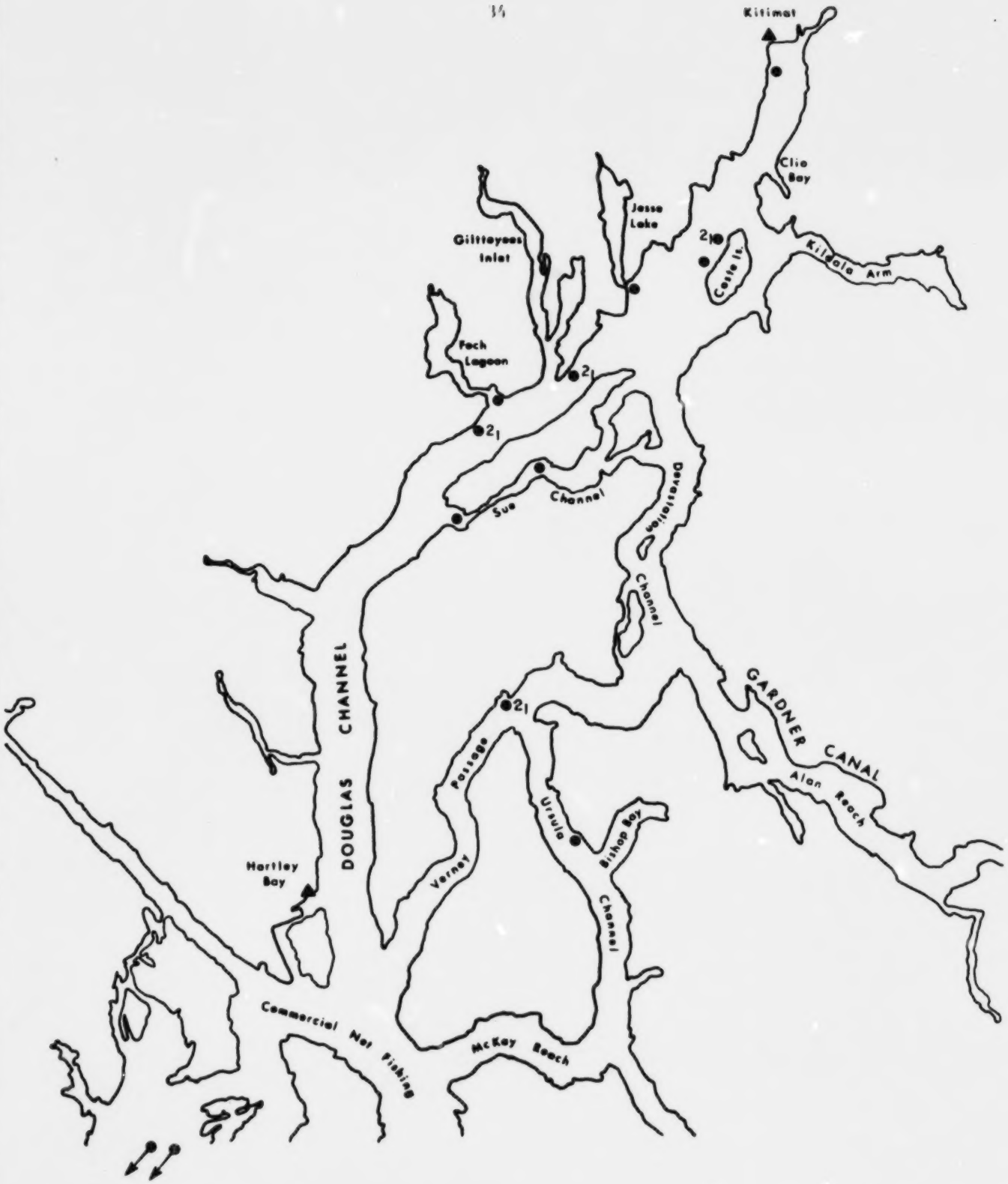


FIGURE 4-4G: Floy Tag Recapture Locations for the Month of May 1981.

TABLE 4-1: Summary of Floy Tag Recapture Locations, by Month.

Subarea	TAG RECAPTURES										
	June 1980 21 tags	July 1980 47 tags	Aug. 1980 39 tags	Sep. 1980 14 tags	Oct.- Feb. 1981 6 tags	Mar.- Apr./ 1981 8 tags	May 1981 13 tags	June 1981 4 tags	July 1981 8 tags	Aug./ Sep. 1981 5 tags	Oct. 1981/ Jan. 1982 4 tags
A - Kitimat Harbour	0	4	1	0	1	1	1	0	0	0	2
B - Coste Island - Jesse Falls	8	6	3	1	0	0	3	0	0	0	0
C - Kildala Arm	0	0	0	0	0	0	0	0	0	0	0
D - Sue Channel	1	2	1	3	1	1	2	2	0	0	0
E - Douglas Channel	3	4	2	0	2	2	3	0	0	0	0
F - Devastation Channel	5	9	10	2	1	2	1	0	0	0	0
G - Outer Waters (Area 6)	3	18	17	7	0	1	1	0	0	0	0
Outside Area 6 (North Coast & Alaska)	1	4	5	1	1	1	2	2	8	5	2

However, it is important to remember that this pattern may reflect the pattern of fishing effort, since CPUE data were unavailable for this period. March and April (1981), recapture patterns are similar to the winter pattern. For the remainder of 1981 the patterns observed in 1980 appear to repeat. Note that 78% of the Floy recaptures in the spring of 1981 are in inlet headwaters, indicating that a substantial portion of this population reared for 2 years in Kitimat Arm.

Table 4-1 summarizes the Floy catches by subarea as a percentage of the total recapture of Floy tags each month.

4.2.3 Kitimat CWT Recoveries in the Commercial Fishery

It should be noted that only 5% of the 2-and 3-year old chinook caught during Floy tagging operations could be attributed to the output of the pilot Kitimat hatchery (see Section 4.3). This indicates that more than 98% of the smolts released by the hatchery emigrated or perished during their first ocean year. The interception of nose tagged Kitimat hatchery fish in the commercial fisheries gives some additional information about the migration patterns of locally produced hatchery stocks. Samples of Canadian landings yielded 45 CWT Kitimat Chinook in 1980, and 46 in 1981. Data from Alaska is less complete, lacking date and location of catch; Alaska reported intercepting 14 Kitimat chinook in 1980 and 57 in 1981. The complete data set on which the following discussion is based is presented in the companion Data Report. These data were conveyed to us by Jim Thomas (pers. comm.).

1980 Canadian Catches

Catches of 1977 brood (3_1) are the most frequent in the commercial catch from the earliest catches in May through mid-July. These are almost exclusively troll caught fish (net fisheries are not open during most of this time) and occurred in Area 6 and areas north (i.e. 1, 2, 4 and 5).

For the period from mid-July through early August, both 1977 and 1978 fish appear in the commercial catches, with 3_1 fish getting caught in the troll fisheries of Areas 6 and 5 and the net fisheries of Area 6; and 2_1 fish appearing only in net fisheries, in Areas 3, 4, 6 and 7.

For the remainder of the season, 1978 brood year 2_1 fish predominate, being caught exclusively in net fisheries, in Areas 3 and 6.

The 2_1 fish are smaller than the 66 cm minimum size limit for the troll fleet and therefore are not recaptured during this fishery.

Applying the appropriate expansion factor, the total estimate of 1980 Canadian commercial interception of these tagged stocks is 150.5 fish (See also Section 5.6.2).

1980 Alaskan Catches

"Commercial fisheries in Alaska have been proven, through catch sampling and mark recovery, to heavily exploit Canadian chinook stocks. Unfortunately, Alaska has encountered numerous problems related to obtaining a representative and numerically sufficient sample. This situation is limiting the function of expanding recoveries and addressing stock contribution." (Jim Thomas, pers. comm.)

The available data originate solely from troll gear and are therefore biased to older age classes. Using an expansion factor of 6.6, the catch estimates are as follows:

Brood Year	Estimated Alaskan Troll Catch
1976 (wild)	13.2
1977 (hatchery)	59.4
1978 (hatchery)	39.6
TOTAL	112.2

1981 Canadian Catches

Catches of 1977 hatchery fish (now 4_1) again are the most frequent (58%) in the early part of the season (May through mid-July), with most catches occurring in the troll fishery. The 1978 hatchery tags (3_1) account for 36% of the catch at this time.

Later in the season, the majority of catches again occur in the net fishery, and 1979 hatchery fish (2_1) account for 60% of the recovered tags.

Applying the appropriate expansion factor, the total estimate of 1981 Canadian commercial interception of Kitimat CWT chinook is 210.5 fish. (See also Section 5.6.2.)

1981 Alaskan Catches

The same reservations described for 1980 Alaska data apply to the 1981 figures.

Brood Year	Estimated Alaskan Troll Catch
1976 (wild)	19.8
1977 (hatchery)	277.2
1978 (hatchery)	158.4
	455.4

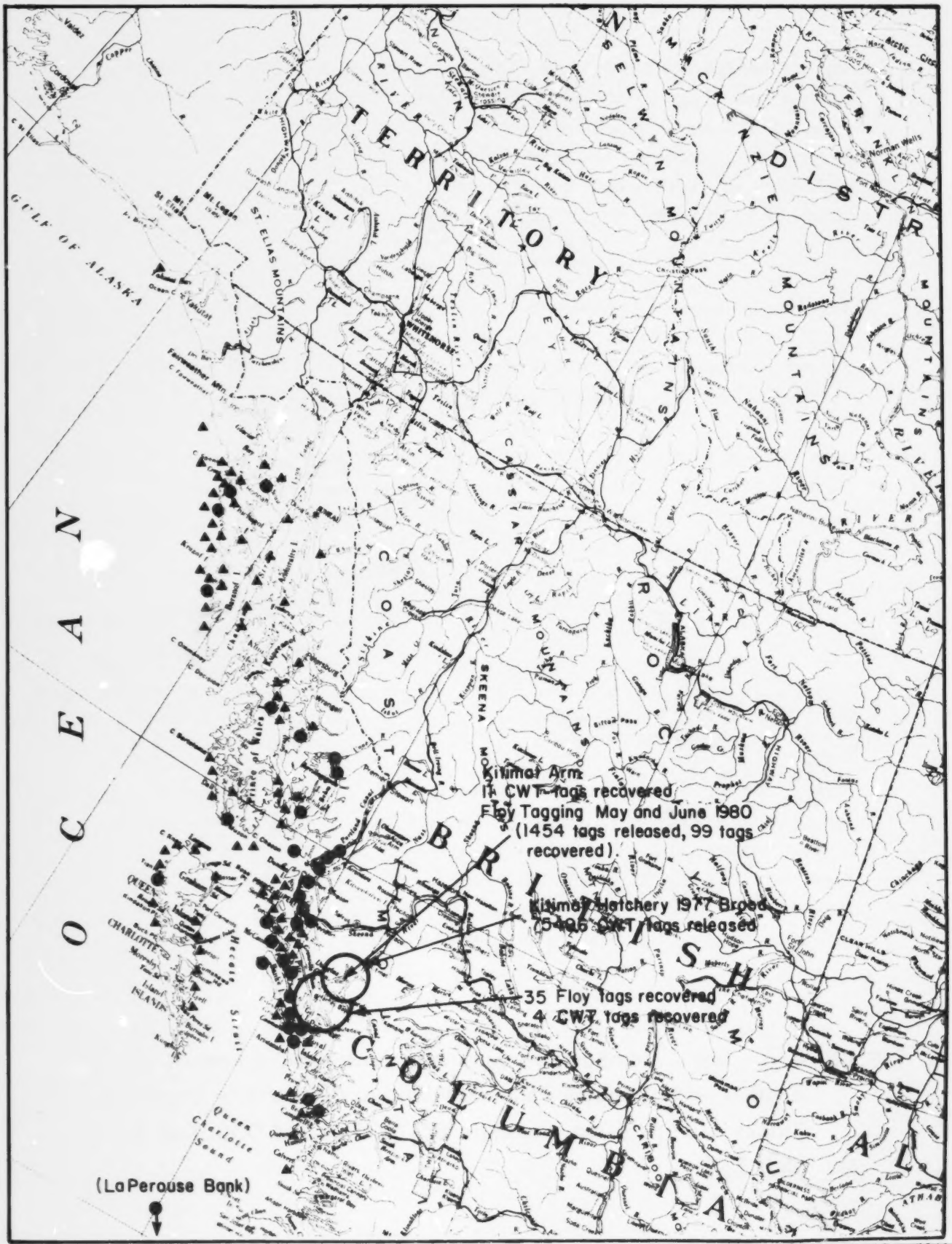
The addition of data from the Alaska troll fishery, while incomplete, clearly indicates that a substantial portion of the Kitimat chinook migrate north into the Alaska panhandle, and indeed that more Kitimat fish are commercially caught in Alaska than in Canada.

4.3 Stock Origins and Composition

The origins of chinook in the Kitimat Arm/Douglas Channel area can be estimated on the basis of the CWT tagged fish caught in the area and the more general information available from scale reading. Figure 4-6 illustrates our findings.

FIGURE 4-5 : Recapture Locations: 39 • Floy tags

▲ Kitimat 1977 CWT (1981 recoveries)



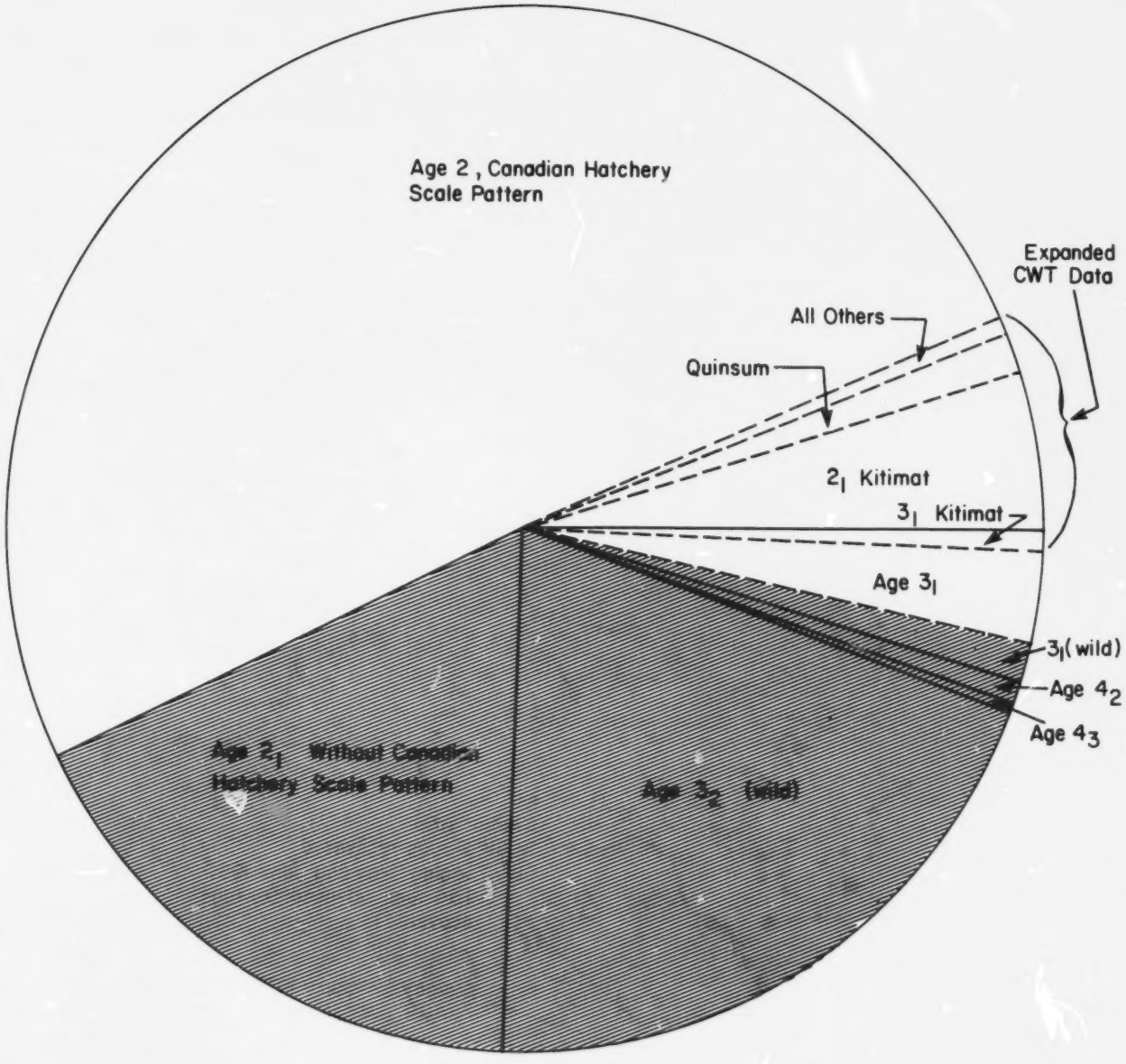


FIGURE 4-6: Stock Composition, May and June 1980 Seine Catch. Shaded Area Denotes Estimated Wild and American Hatchery Stocks. (Population Estimate 55,000 ± 27,000 Age 2_1 and 3_2).

The seine operations in the study area caught 45 adipose-clipped chinook juveniles out of 1,437 fish caught (1,454 salmonids minus 27 non-chinook), indicating that approximately 3.1% of the population was tagged. The sport landings covered by the creel census had 2.7% adipose-clipped fish. As shown in Figure 3-1, the sport catch had a substantial proportion of larger fish. Therefore, this report uses the round figure of 3% tagged for the population of 2_1 and 3_2 fish.

This proportion of tags is much lower than anticipated, since approximately ½ of the Kitimat hatchery fish were tagged, and local stocks were believed to be greatly reduced. This implies that more than 98% of Kitimat hatchery fish are leaving the inlet during their first ocean year, at sizes between 5 and 12 inches.

Table 4-2 shows a summary of the data from 116 nose tagged fish that were caught in the sport fishery in 1980 and were decoded by DFO (see also companion Data Report). Table 4-3 shows the corresponding data for 1981; note that an increase in the size limit for sport catches eliminated the reporting of catches of age 2_1 fish. Fishing effort was less in 1981, and tag awareness appears to have declined sharply (Jim Thomas, pers. comm.).

4.3.1 The 1978 Brood Year Stocks

Table 4-2 shows that approximately 85% of the tagged 2 year-old fish present in 1980 were from the Kitimat hatchery. In 1981, this proportion remains relatively unaltered at 83% (Table 4-3), which may in part be due to the increase in size limit causing the sport harvest to shift to 3-year old fish and thus harvest the same 1978 brood fish as in the previous year. Records from the Kitimat hatchery indicate that approximately one half of the smolts from the 1978 brood year were nose tagged (Sylvia Willis, pers. comm.). So for the 1980 estimated population (late June) of 55,000 aged 2_1 and 3_2 fish, the estimated number of Kitimat hatchery fish is: $55{,}000 \times 0.03 \times 0.85 \times 2 = 2{,}805$.

The scale reading data, in which Canadian hatchery fish were identified by a distinctive scale pattern (see Section 3.3.3), indicated that 30% of the sport

TABLE 4-2: Origins of Coded-Wire Tagged Chinook Caught in the Kitimat Arm Sport Fishery, 1980 (Size limit 12 inches).

Stock	Creel Census Data Only	%	Total Head Recoveries March April	May-June	July-Aug.	Aug.-Sept.	Total	%
lost head, lost pin, no pin	26		3	0	3	0	6	
1978 Brood								
Kitimat '78	23	85.2	10	20	14	6	50	84.7
Squamish '78	1	3.7	0	1	1	1	3	5.1
Quinsam '78	3	11.1	0	0	1	2	3	5.1
Willamette '78	0	-	0	0	0	1	1	1.7
Puntledge '78			0	0	0	1	1	1.7
Big Qualicum '78			0	0	1	0	1	1.7
Totals			10	21	17	11	59	
1977 Brood								
Kitimat '77	10	62.5	20*	11	3	1	35	74.5
Klickitat '77	2	12.5	4	0	0	0	4	8.5
Elk River '77	1	6.3	1	0	0	0	1	2.1
Atnarko '77	1	6.3	1	0	0	0	1	2.1
Bonneville '77	1	6.3	0	0	1	0	1	2.1
Quinsam '77	1	6.3	0	0	0	1	1	2.1
Big Qualicum '77	0		0	1	0	0	1	2.1
Capilano '77	0		0	1	0	0	1	2.1
Oakridge '77	0		0	1	0	0	1	2.1
Cowlitz '77	0		1	0	0	0	1	2.1
Totals			27	14	4	2	47	
1976 Brood								
Quinsam '76	5		2	3	0	0	5	55.6
Puntledge '76	1		0	1	0	0	1	11.1
Priest '76	1		0	1	0	0	1	11.1
Cowlitz '76	0		1	0	0	0	1	11.1
Columbia '76	0		1	0	0	0	1	11.1
Totals			4	5	0	0	9	
1975 Brood								
no CWT recoveries								
1974 Brood								
Columbia '74	0		0	0	1	0	1	

* Includes 17 hatchery and 3 wild tags.

TABLE 4-3: Origins of Coded-Wire Tagged Chinook Caught in the Kitimat Arm Sport Fishery 1981 (Size limit 18 inches).

Stock	Head Recoveries				
	Jan-Feb	March-May	June	Total	%
1979 Brood					
No CWT Recoveries Reported (note change in size limit)					
1978 Brood					
Kitimat 1978	1	5	4	10	83.3
Quinsam 1978	0	0	2	2	16.7
Total	1	5	6	12	
1977 Brood					
Capitano River 1977	0	1	0	1	100
1976 Brood					
No CWT Recoveries					
1975 Brood					
Quinsam River 1975	0	0	1	1	100

catch and 58% of the seine catch were hatchery fish. Since many established hatcheries tag only a small portion of their smolts, the CWT data can only be used as a general indication of the origins of these hatchery fish. (Note that Figure 4-6 is based on expanded CWT data.)

The CWT data indicate that only 15% of the tagged 2-year old fish and 25% of the 3-year old fish originated from outside the local area. The distribution of hatchery fish may be different from that of wild stocks. The proportions of local versus immigrant fish may be quite different in wild stocks as opposed to hatchery stocks, since the latter clearly have an altered life history and are released into the ocean at a larger size for their age.

The 1980 CWT data indicate 5% of the tagged 2 year old population was from the Squamish hatchery, and 5% from Quinsam. The Puntledge and Big Qualicum hatcheries were each represented by one CWT fish from the 1978 brood, as was the Willamette hatchery in Oregon.

In summary, it is clear that Kitimat hatchery fish are by far the most common of the identified stocks, but their actual abundance accounts for only 5% of the local 2-year old population. Quinsam stocks are the most common of the other identifiable stocks.

4.3.2 The 1977 Brood Year Stocks

In 1980, the 3-year old fish bearing coded-wire tags also show a predominance of Kitimat hatchery tags, with the total head recovery data indicating 74.5% and the creel census data indicating 62.5%. The next most common tag code is from the Klickitat hatchery in Washington, and there are also single recoveries from 6 B.C. hatcheries and 2 Oregon hatcheries. Data from 1981 are too incomplete to contribute information.

The overall picture suggests that chinook range more widely (and further north) in their second ocean year.

There is one interesting item to note in 1980 CWT recoveries, comparing 1977 and 1978 brood years. Fifty (50) Kitimat fish were taken from the large sample (65%) of 2-year olds caught in the sport fishery, while 35 Kitimat fish were caught in the small sample (15%) of 3-year olds (see Table 5-12). The original numbers of these tags released were almost identical: 75,469 for 1977 (almost all smolts bore tags) and 73,436 for 1978 (approximately ½ of the smolts released). Mathematically one would predict that if the tagged proportion of the population remained equal, then the same fishing exploitation would have produced only 23 tagged 3-year olds. There are several possible interpretations of this comparison: 1) Kitimat hatchery fish that winter in the inlet may be less likely to leave the study area during their second ocean year than the autochthonous fish - this may have some implications for competition with younger fish from local wild stocks if hatchery production increases the numbers of these older residential fish; 2) the 1978 hatchery reared fish, released as part of the largest production (151,771) from the pilot hatchery facility, may have experienced a much higher mortality or early emigration rate than the previous year's production of one half the number of fish - this may have implications relative to the rearing capacity of inlet waters.

4.3.3 The 1976 - 1974 Brood Year Stocks

The CWT recaptures indicate that Quinsam hatchery is the most common tag code observed, with single recoveries from two other B.C. hatcheries and 2 Washington State hatcheries as well.

No 1975 brood year CWT were recovered. One fish from the 1974 brood from a Columbia River hatchery was recaptured.

4.3.4 Wild Stocks

Although no quantitative estimates can be made of the stock composition of unmarked stocks in the area, it should be noted that only 15% of the readable scales showed a fresh water annulus (Table 5-12) - e.g. ages 3_2, 4_2, 4_3 and 5_2. Although a portion of wild fish probably smolt in their first year, it is believed

that a majority of the wild chinook of the central coast area grow slowly in freshwater and do not smolt until the second or third year (Yvonne Yole & Sylvia Willis, personal communications). It is likely that wild stocks contributed less than a quarter of the Kitimat Arm population in 1980, and that only a fraction of these were local wild stocks. As stated in Section 4.3.1, the majority of unmarked chinook in the May and June seine sample showed the scale patterns of Canadian hatchery fish.

4.3.5 Conclusions

Our results show that the mixed population of 2 and 3 year old chinook that rear in the Kitimat Arm/Douglas Channel area are predominantly (58%) from Canadian hatcheries outside the local area. Of the fish produced by the pilot Kitimat hatchery, 98% had moved out of the local area less than 1 year after their release.

5.0 THE SPORT FISHERY OF KITIMAT ARM

5.1 Socio-Economic Perspective & Recent History

For the relatively isolated and affluent towns of Kitimat and Terrace, fishing is the primary recreational activity. A socio-economic study of the area in 1974 (Sinclair, 1975) found that fully one-third of the residents of these two towns are sport fishermen, and that 40% of the households of Kitimat participate in outdoor recreation regularly (averaging 0.62 times per week). Kitimat is in some ways a unique town, having been created suddenly to provide accommodation for the employees of the Alcan aluminum smelter in 1951. The town has two major employers, Alcan and the Eurocan pulp mill,which opened in 1970. Sinclair found that more than 50% of the residents of Kitimat had lived there less than 10 years, and 64% did not expect to still be living in Kitimat 10 years hence. In other words, despite high wages, low unemployment levels and the attractive residential environments of the town, there is little feeling of permanence or attachment. Sinclair's findings indicate that enjoyment of the outdoor recreational opportunities of the area is appreciated by residents as a form of compensation for living in Kitimat.

Interviews of streamside "recreationists" (Kitimat River) in 1974 (Sinclair, 1975) found that 20.4% of those interviewed chose fishing as the single most important advantage of living in Kitimat, while only 2.5% chose hunting and 0.4% chose boating. At this time,there was relatively little boating activity. The records of the MK Bay Marina indicate that only 35 boats rented moorage in 1976 (Don Pearson, pers. comm.). DFO records show an estimate of 930 boat-days effort for the Kitimat area for 1971 (Fisheries & Marine Service, 1972).

Angling in the Kitimat River attracted 60% of all sport fishing activity of the local residents. Sinclair estimated 104,000 angler days on the Kitimat River in 1974, making it one of the most active sport fishing rivers in Canada. The popularity of river fishing was partly explained by lower cost (estimates of $5.35 per day for fishing the Kitimat River versus $22.90 per day to fish Douglas Channel) and high accessibility.

Since 1974,several factors have combined to turn sport fishing effort away from the Kitimat River to salt water. There has been a decline in the quality of river fishing, culminating in the nearly complete closure of the Kitimat River in 1980 for the protection of seriously reduced spawning stocks. There has also been steady growth in marina facilities and increasingly larger boats and charter facilities.

Sport fishing effort in Kitimat Arm has increased in magnitude since 1971:

	Period	Boat-Days	Reference
1971	12 months	930	(DFO records)
1978	May 25 - Oct. 10	2,497	(Masse, 1980)
1980	May 10 - Sept. 30	3,520	(this study)

A sport fishing survey in Kitimat Arm was undertaken in 1978 by the Recreational Research Unit of the Dept. of Fisheries & Oceans (Masse, 1980) which provides a basis for evaluation of the degree to which this increase in sport fishing effort has had an impact on the chinook population. Details of the 1978 findings are compared with the 1980 results in the following sections.

5.2 1980 Sport Catch & Fishing Effort Summary

The synopsis of catch and effort estimates based on the creel census is presented in Tables 5-1 and 5-2 to provide a basis for the detailed examination of the data that follows. (See Table 3-2 for the details of creel census coverage and non-fishing boating.) All of the estimates in Tables 5-1 and 5-2 and below are based on the observations of the creel census expanded by the percent coverage (see Section 3.3.1) and are subject to rounding error.

TABLE 5-1: Chinook Catch, Angler-Effort and Estimated Total Catches by Month & Subarea.

	May	June	July	August	September	Total
A. Angler Days Effort by Month and Subarea - Creel Census Data Only						
A	13	9	59	44	42	167
B	104	183	202	293	134	916
C	0	20	20	55	57	152
D	81	136	142	172	150	681
E	15	90	68	110	68	351
F	62	134	102	235	125	658
G	18	45	82	325	132	602
Total	293	617	675	1234	708	3527
B. Chinook Catch by Month and Subarea - Creel Census Data Only						
A	7	5	27	2	21	62
B	138	190	162	74	23	587
C	0	14	5	1	1	21
D	151	198	153	56	61	619
E	16	65	46	20	4	151
F	133	223	135	148	42	681
G	32	76	136	258	59	561
Total	477	771	664	559	211	2682
C. Estimated Total Catches by Month						
Chinook	1383	2089	1819	1341	450	7082
Other Sal.	23	16	403	796	226	1464
Under-size Salmonids	1675	1588	803	1089	889	6044
Total	3081	3693	3025	3226	1565	14590

TABLE 5-2: Weekly Synopsis of Estimated Sport Fishing Effort & Chinook Catch (based on creel census data), 1980.

	Total Boat-Days*	Total Angler Days	Creel Census Coverage (percent)	Mean Catch/ Angler-Day		Total Chinook Catch		Mean Catch/ Boat-Day*
May 10-11	29	76	17.2	1.82	0.26	138	20	4.76
May 12-18	96	221	45.8	2.08	0.48	460	106	4.79
May 19-25	127	329	34.6	1.60	0.09	516	30	4.06
May 26 - June 1	120	306	31.7	1.31	0.66	402	217	3.17
June 2-8	140	354	31.4	1.11	0.66	391	234	2.79
June 9-15	141	358	46.1	1.46	0.28	521	102	3.70
June 16-22	111	257	31.5	1.39	0.28	358	73	3.23
June 23-29	134	338	38.8	1.23	0.65	415	222	3.10
June 30 - July 6	204	517	41.2	1.24	0.32	640	167	3.14
July 7-13	133	342	36.8	0.71	0.50	242	171	1.82
July 14-20	130	340	30.0	0.90	0.63	307	214	2.37
July 21-27	167	442	37.1	0.95	0.37	421	166	2.52
July 28 - August 3	179	483	35.2	0.77	0.35	370	169	2.07
August 4-10	319	792	38.9	0.80	0.43	632	340	1.98
August 11-17	122	308	39.3	0.42	0.35	128	108	1.05
August 18-24	179	467	47.5	0.41	0.33	193	155	1.08
August 25-31	229	564	51.1	0.26	0.10	145	56	0.63
September 1-7	220	547	39.1	0.19	0.15	102	82	0.46
September 8-14	178	415	49.4	0.35	0.29	147	119	0.83
September 15-21	90	194	51.1	0.17	0.18	33	35	0.37
September 22-28	61	140	44.3	0.25	0.29	35	41	0.58
Totals	3,109	7790				6,596	719	

* Does not include boats that were not salmon fishing.

A weekly synopsis of effort and catch is presented in Table 5-2.

(Note that the estimated number of chinook caught, 7082, calculated as a direct expansion of creel census observations, is different from the estimate of 6596 ± 719 (Table 5-2) based on weekly catch effort (method described in Section 3.3.1) but is within the standard deviation of that estimate.)

5.3 Description of the Sport Fishermen of Kitimat Arm

5.3.1 Angler Origins & Success

Despite a past record of excellent salt water fishing, the Kitimat Arm area is not as attractive to distant fishermen as some of the more southerly areas, such as Rivers Inlet or Campbell River. The fishery is predominantly a local one, with residents of Kitimat and Terrace accounting for 66% of the fishing effort and catching 70% of the chinook harvest (Table 5-3). B.C. residents from other parts of the province account for 24.7% of the harvest, with anglers from other provinces and countries accounting for only 5.3%. (See companion Data Report for original creel census data in effort and catch by residence of angler and subarea fished.)

TABLE 5-3: Effort & CPUE by Residence of Anglers.

	Kitimat		B.C.		Canadian		Foreign	
Month	Days Effort	Chinook CPUE	Days Effort	Chinook CPUE	Days Effort	Chinook CPUE	Days Effort	Chinook CPUE
May	556	1.60	281	1.73	12	0.25	0	-
June	1127	1.35	447	0.97	43	0.94	54	1.50
July	1312	1.08	307	0.63	159	1.16	71	0.42
August	1810	0.44	978	0.53	93	0.18	76	0.06
September	1066	0.31	356	0.29	57	0.37	30	0.00
Total	5871		2369		364		231	
Mean		0.80		0.70		0.69		0.47
% of Chinook Harvest		70.0%		24.7%		3.7%		1.6%

Local residents are also somewhat more successful in their fishing. This may be due to familiarity with the area and habits of the fish. Another important factor is the fact that most charters operating out of Kitimat do not go to the outer coast when the fish have moved out, and thus people using these services in the summer must fish in the upper inlet waters where fish abundance is low. This can be examined in more detail in the companion Data Report which provides a breakdown of catch and effort data by residence of the angler and subarea fished.

5.3.2 Boat Types & Ownership

The Kitimat Arm sports fishing fleet is growing rapidly, both in number and size. In 1980 there were 3 public marinas in Kitimat providing moorage for 252 boats averaging 24 feet in length. In addition, there are at least three docks or beaches where boats can be launched; Alcan maintains several boats at its private dock; and the Kitimaat Indian Village also has some moorage. Marina managers reported 10 to 15% growth in their operations in 1981.

Examination of the boats used by interviewed fishermen showed that boat owners and their non-paying passengers accounted for the majority of angler days (Table 5-4). No one ever reported paying rent for a boat. Charters account for 15.5% of all angler days, and 15.3% of the chinook harvest. (This includes both locally operated charters in Kitimat and the large charter boats operating in the outer waters of the study area.)

TABLE 5-4: Percent Effort (May through September) & CPUE by Boat Ownership.

	Angler Days	CPUE	% of Chinook Harvest
Owned by Angler	35.4	0.88	40.8
Passenger on Privately Owned Boat	49.1	0.68	43.9
Charter Boats	15.5	0.75	15.3

Although sailing is popular in Kitimat, motorized boats account for virtually all of the fishing effort, probably because sail boats are not suitable for trolling. Outboard motored boats are used for many more angler-days than inboards (1.64 to 1.0) but catch fewer chinook (0.94 to 1.0). The mean catch per angler-day (not boat-day) in an outboard is 0.57 versus 1.00 for anglers using inboards. Part of the difference in fishing success is probably attributable to the greater distance range of inboards.

5.3.3 Boat Size

The average size of boats used in Kitimat Arm is growing rapidly, from a mean of 18' in 1976 to a mean of 24' in 1980 (Don Pearson, pers. comm.).

Since Kitimat Arm is the main launching site in the area, the ability to "follow the fish out" is closely linked with success as the season progresses. Figure 5-1 shows the catch per angler day in each of the subareas. Table 5-5 shows apparent correlations between the size of the boat used and the distance travelled with the catch per effort. Since travelling time detracts from fishing time, these figures have been shown as catch per hour of effort (i.e. fishing time only).

TABLE 5-5: Catch per Hour Effort, by Boat Size and Subarea.

	BOAT LENGTH (feet)					
Subareas	<15	16-20	21-25	26-30	31-40	Mean
A - Kitimat Harbour	0.115	0.176	0.034	0.167	0.087	0.117
B - Coste Is/Jesse	0.120	0.197	0.202	0.144	0.150	0.165
C - Kildala Arm	0.039	0.027	0.073	0.0	-	0.032
D - Sue Channel	0.174	0.238	0.244	0.109	0.200	0.204
E - Douglas Channel	0.046	0.168	0.143	0.190	0.0	0.121
F - Devastation Channel	0.144	0.274	0.248	0.190	0.228	0.220
G - Outer Waters	0.130	0.209	0.210	0.276	0.667	0.183
Mean CPUE	0.132	0.212	0.203	0.175	0.201	0.177

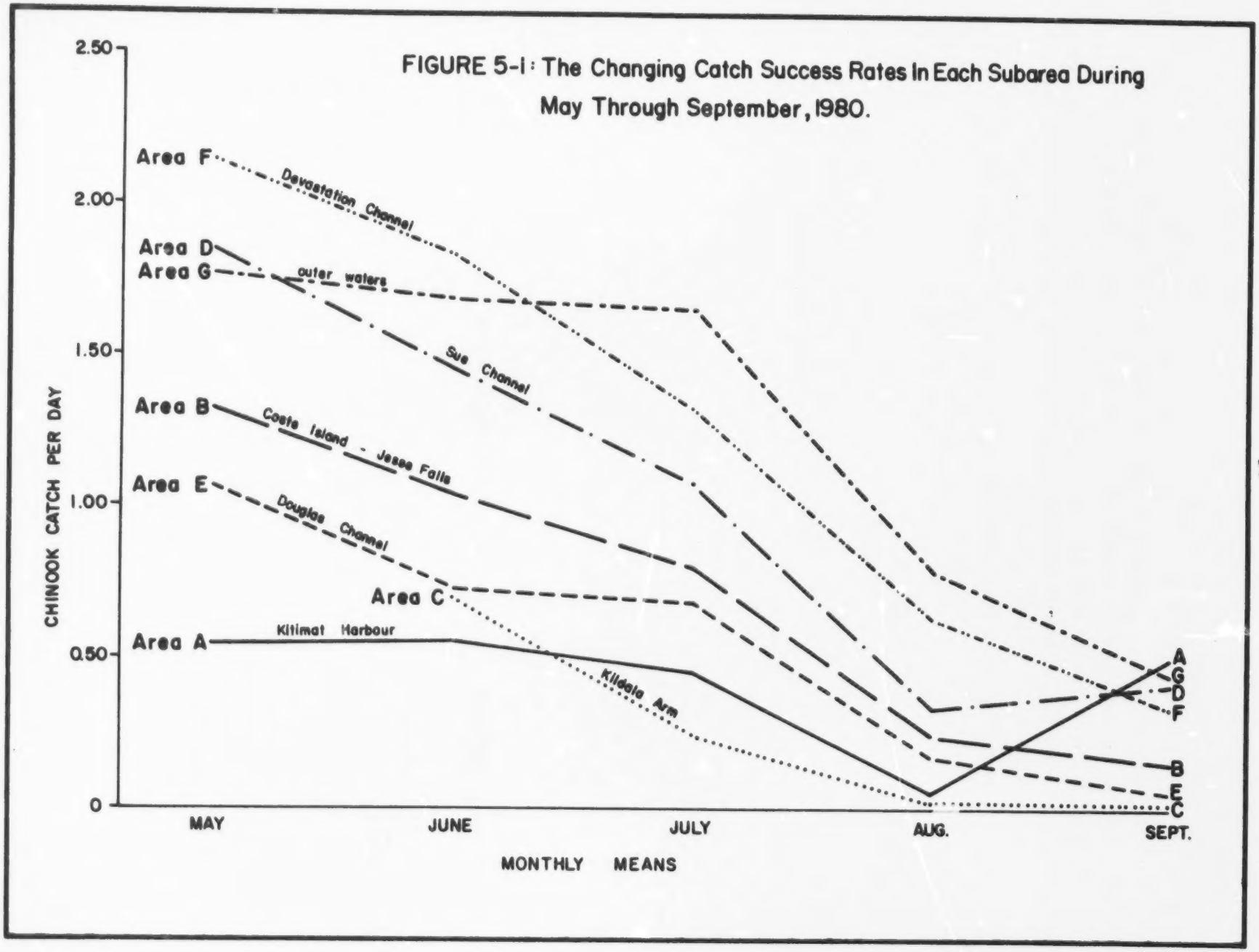


FIGURE 5-1: The Changing Catch Success Rates In Each Subarea During May Through September, 1980.

5.4 Locations of Fishing Effort and Success

The 7 subareas used to monitor the population as the chinook changed their distribution and abundance also serve to show the changing distribution and abundance of the fishermen. These figures reflect the chinook migration patterns discussed in Section 4.2.

TABLE 5-6: Angler Days Fishing Effort by Subarea & Month (creel census data expanded by % coverage; subject to rounding error).

Subarea	May	June	July	Aug.	Sept.	Seasonal Total
A - Kitimat Harbour	38	24	162	106	90	420
B - Coste Is/Jesse Falls	301	496	553	703	286	2339
C - Kildala Arm	0	54	55	132	122	363
D - Sue Channel	235	368	389	412	320	1724
E - Douglas Channel	43	244	186	264	145	882
F - Devastation Channel	180	363	279	564	267	1653
G - outer waters	52	122	225	779	281	1459
Total - All Areas	849	1671	1849	2960	1511	8840

The changing CPUE of the individual subareas is graphed in Figure 5-1 to show their changing relationship of fishing success over the season.

To place the Kitimat catch rates in perspective, they have been compared with sport catches in Georgia Strait (Statistical Areas 13-20, 28 and 29) in 1975 and 1976 (Harris, et al., 1978) (Table 5-7). These data are taken from log book fishermen, who on the whole are better and more frequent fishermen than average. Therefore,the Georgia Strait CPUE's are biased upwards to an unknown degree.

TABLE 5-7: Catches per Angler Day in Kitimat Arm & Georgia Strait.

Month	Kitimat Arm 1980 Creel Census	Georgia Strait, 1975 & 1976, log book Fishermen
May	1.63	0.72
June	1.25	0.67
July	0.98	0.78
August	0.45	0.82
September	0.30	0.80
5 Month Mean	0.76	0.77

It is interesting to note that despite the decline in the quality of fishing in Kitimat Arm, the catch rate of average fishermen was higher in May, June and July than the catch rates of better-than-average fishermen in the waters of Georgia Strait.

5.4.1 Relationship Between CPUE and Future Effort

Generally, it is expected that people will be more willing to fish when the fishing is good, and that their interest will drop if the catch rate drops. In other words, a positive correlation is expected between the catch rate of one period and the effort expended in the following period. This is clearly not the case in the Kitimat Arm area, where effort increases during the summer while catch rates are declining. (Although coho catches peaked in August, they never exceeded 60% of the monthly chinook catch.) Obviously, the enjoyment of recreational boating is a more important factor in the decision to "go fishing" than the likelihood of catching a fish. However, once having decided to go fishing, the decision of where (i.e. which subarea) to go might be considered to be influenced by recent fishing success in the different subareas. To test this hypothesis Kendall's Coefficient of Rank Correlation (Hollander & Wolfe, 1973) was used to test for the presence of a correlation between fishing success (i.e. catches per angler-day) in each subarea for a given week with the distribution of effort to each subarea in the following week.

Initial Week of CPUE	Subsequent Week of Effort Data	Kendall's Coefficient τ
5/12 - 5/19	5/20 - 5/25	22
5/20 - 5/25	5/26 - 6/1	14
5/26 - 6/1	6/2 - 6/8	14
6/2 - 6/8	6/9 - 6/15	6
6/16 - 6/22	6/23 - 6/29	2
6/23 - 6/29	6/30 - 7/6	-2
6/30 - 7/6	7/7 - 7/13	-6
7/7 -7/13	7/14 -7/20	-10
7/14 - 7/20	7/21 -7/27	22
7/21 - 7/27	7/28 - 8/3	6
7/28 - 8/3	8/4 - 8/10	14
8/4 - 8/10	8/11 - 8/17	14
8/11 - 8/17	8/18 - 8/24	18
8/18 - 8/24	8/25 - 8/31	22
8/25 - 8/31	9/1 - 9/7	22
9/1 - 9/7	9/8 - 9/14	10
9/8 - 9/14	9/15 - 9/21	-6
9/15 - 9/21	9/22 - 9/28	14

The critical value of τ for confidence at the $\alpha = 0.05$ level is 30. The highest value obtained was 22, and there were several negative τ's indicating the possibility of a negative correlation. Therefore, we must conclude that the decision of where to go fishing is not correlated with the fishing success of the different subareas during the previous week.

Clearly there are factors, involved in the decision, that are more important than the relative quality of fishing. The most important factor may be the suitability of the boat for travelling long distances and staying out overnight. In general, the fishery behaves as if recreational boating is the main pursuit, and fishing a secondary consideration.

5.5 Baits & Fishing Method

5.5.1 Utilization & Success

Anglers everywhere have their own theories on the optimal baits and fishing method to use. Of particular interest in this case was the relative attractiveness of different baits to fish of different sizes.

The method of fishing used is almost exclusively trolling, with the main variation being the use of downriggers which do increase the catch rate. Catches of all salmon species have been included in the figures of Table 5-8.

TABLE 5-8: Effort & Catch by Fishing Method.

	% Total Days Effort	Salmon CPUE	Under-size Salmonid CPUE
Trolling without downriggers	56.6	0.71	0.45
Trolling with downriggers	34.4	1.18	0.97
Casting from boat or shore	3.8	0.81	0.22
Other methods	5.2		

Herring strip is by far the most popular bait used in the Kitimat Arm area and is used for 66% of all fishing effort (Table 5-9). It is also the most successful bait over all subareas, having a mean catch per day of 0.81 chinook.

Hoochies and spoons produced the best catch rates in the outer areas (subarea G), and appear to catch slightly larger fish in all subareas. It is left to the experienced fishermen of the area to argue over the deeper implications of Table 5-9.

The catchability of under-size fish to each bait type is discussed in Section 5.6.3.

TABLE 5-9: Mean Catch per Angler-Day and Mean Lengths of Chinook Caught, by Bait and Subarea.

Bait	Subarea A	B	C	D	E	F	G	Mean - All Areas
A. Legal Size-Chinook								
Herring Strip	0.33	0.70	0.11	0.95	0.49	1.18	0.77	0.81
Spin-n-Glo	0.50	-	2.00	0.0	0.0	-	-	0.56
Hoochies	0.81	0.37	0.0	0.80	0.52	0.75	1.34	0.80
Spoons	0.27	0.57	0.12	0.88	0.28	0.72	1.12	0.63
Needlefish	0.11	0.58	0.0	1.15	0.07	0.75	1.03	0.70
Combination	-	0.48	0.0	0.20	0.0	1.11	0.0	0.50
Whole Herring	0.17	0.07	0.40	0.63	0.47	0.91	0.89	0.52
Other*	-	0.0	-	0.0	0.0	0.75	-	0.33
Mean (all baits)	0.37	0.64	0.14	0.91	0.43	1.03	0.93	0.76
B. Under-Size Salmon								
Herring Strip	0.22	0.40	0.27	0.78	0.31	1.17	0.86	0.67
Spin-n-Glo	0.0	-	0.0	0.0	2.33	-	-	0.33
Hoochies	0.33	0.63	0.25	0.70	0.16	0.77	1.13	0.73
Spoons	1.40	0.57	0.04	0.57	0.22	0.76	1.08	0.60
Needlefish	0.22	0.94	0.0	1.00	0.50	1.00	0.50	0.73
Combination	-	0.43	0.0	2.40	0.0	0.67	0.36	0.76
Whole Herring	0.0	0.07	0.60	0.50	0.0	1.18	0.56	0.39
Other*	-	0.0	-	0.0	0.0	0.0	-	0.0
Mean (all baits)	0.33	0.45	0.13	0.77	0.27	1.02	0.91	0.66
C. Mean Lengths (inches) of Chinook Caught (excluding undersize fish)								
Herring Strip	20.9	16.5	17.6	17.1	18.5	18.4	18.6	17.7
Spin-n-Glo	16.0	-	27.3	-	-	-	-	25.0
Hoochies	19.6	16.4	-	18.2	16.4	19.2	19.6	18.8
Spoons	24.5	17.3	20.8	18.1	16.1	18.7	19.3	18.6
Needlefish	23.0	13.4	-	18.0	16.0	19.3	17.2	17.0
Combination	-	15.4	-	16.5	-	15.1	-	17.3
Whole Herring	14.0	16.0	25.0	18.5	17.0	16.4	15.4	17.4
Other*	-	-	-	-	-	21.7	27.0	24.3
Mean (all baits)	20.7	16.4	21.7	17.4	17.8	18.4	18.9	17.9

* "Other" category consisted of cod jigs, bacon, ham and no bait. In addition, 5 days of effort were reported using 'plastic herring' but the catch was nil.

\- indicates no effort was recorded using this method

0.0 indicates that there was effort but no catch

5.6 Size and Age of Catch

5.6.1 Lengths & Weights of Sport Catch

DFO records indicate a dramatic increase in the catch of chinook under 5 lbs. between 1978 and 1979 (Figure 5-2). The high catch of smaller fish was further increased in 1980. Table 5-10 shows the comparison of mean weights compiled from the 1978 creel census data (Masse, 1980) and the 1980 creel census data.

TABLE 5-10: Comparison of Mean Weights of Chinook Sport Catches between 1978 & 1980 by Subarea & Month.

1978 Zone	1978 Mean Wt. (lbs)	1980 Zone	1980 Mean Wt. (lbs)
1 - Head of Inlet	3.76	A - Kitimat Harbour	7.82
2 - Douglas/Sue Ch.	5.36	B - Coste I/Jesse	3.07
3 - Ursala/Devastation Ch.	5.51	C - Kildala Arm	9.57
4 - Gardner Canal	6.36	D - Sue Channel	3.00
5 - Outer waters	5.33	E - Douglas Channel	3.31
Overall Mean	4.83	F - Devastation Channel	3.47
		G - Outer waters	3.55
		Overall Mean	3.51

Month	Mean Wt. (lbs.) 1978	1980
May	4.18	(insufficient data)
June	4.48	7.44
July	4.72	3.74
August	7.07	3.07
September	7.21	3.63
October	7.75	-
Overall Mean	4.83	3.51

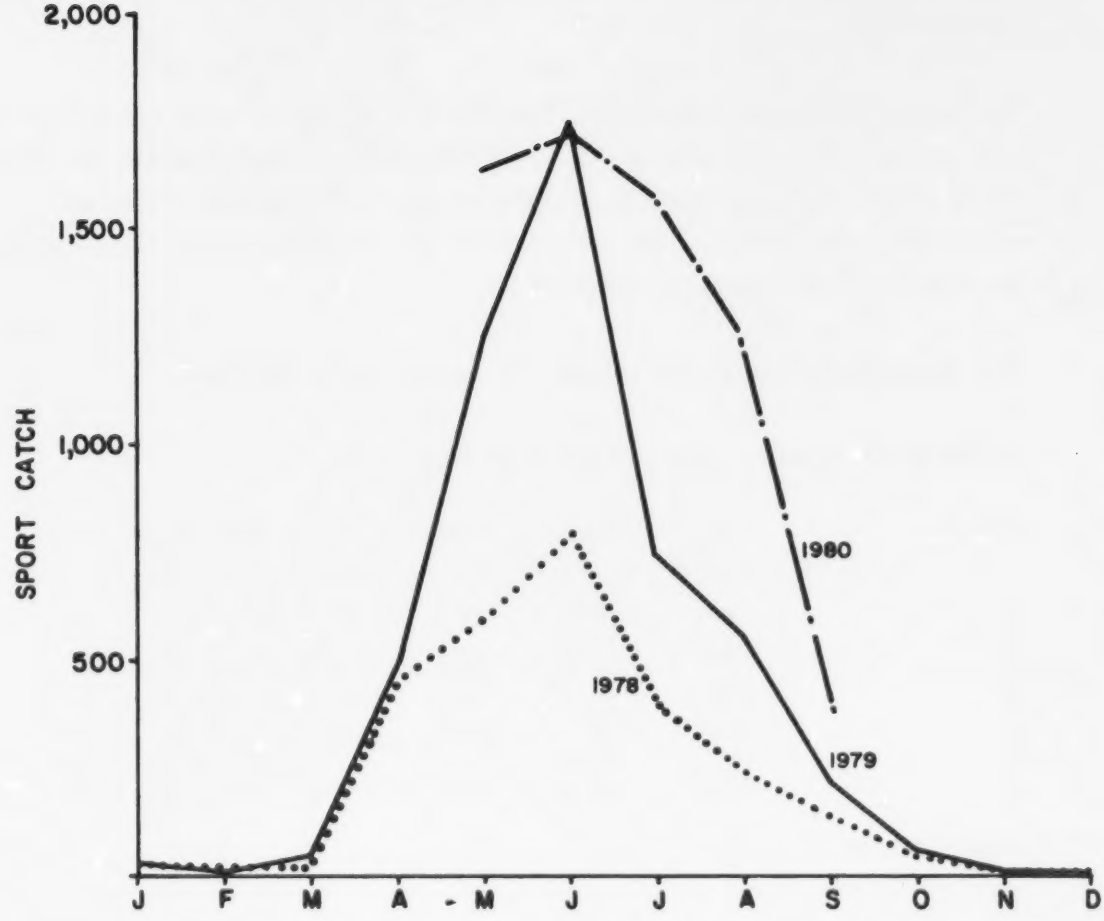


FIGURE 5-2: Estimated Sport Catches of Chinook ≤ 51bs.

* NOTE: 1978-1979 figures based on DFO records, 1980 figures based on Creel Census Data.

The fish caught in 1980 were predominantly (66%) in the 14" to 18" (35 to 45 cm) length range (mean length = 17.9 inches, modal length = 16 inches). The mean weight of 4.83 lbs (2.19 kg) observed in 1978 corresponds to a chinook in the size range of 19" to 22" (48 to 55 cm). (Length /weight relationship computed on 1980 data.)

The length frequency distribution (Figure 5-3) of the entire sport catch in May through September 1980 (calculated on data from 707 catches of single fish only) shows a skewed distribution. The length frequency distributions of the separate age classes contributing to the catch are shown in Figure 5-4, and the percent contributions are discussed in Section 5.6.2.

The mean lengths observed by subarea and month were as follows:

TABLE 5-11: Mean Lengths (inches) by Subarea and Month.

Subarea	May	June	July	August	September	Seasonal Mean
A	14.9	18.4	23.2	14.0	20.5	20.7
B	16.7	16.1	16.5	16.6	15.0	16.4
C	-	20.6	24.6	17.0	26.0	21.7
D	17.6	17.4	17.1	17.4	17.5	17.4
E	16.6	18.7	16.4	18.1	23.5	17.8
F	20.1	18.4	18.5	17.0	19.5	18.5
G	21.6	22.0	18.9	17.9	17.6	18.8
Mean - All Areas	18.2	18.0	17.9	17.4	18.1	17.9

5.6.2 Age Classes of Sport Catch

Scales collected by the creel census technicians and interpreted by the Department of Fisheries & Oceans indicate that the main peak (14 to 18 inches) in the length frequency (Figure 5-4) consists of 2_1 and 3_2 age fish, while the larger fish are primarily age 3_1. It is clear that the 2_1 age category contributed the majority of the catch in 1980. But the average size (48 to 55 cm) of chinook caught in 1978 appears to correspond to the 3_1 age class.

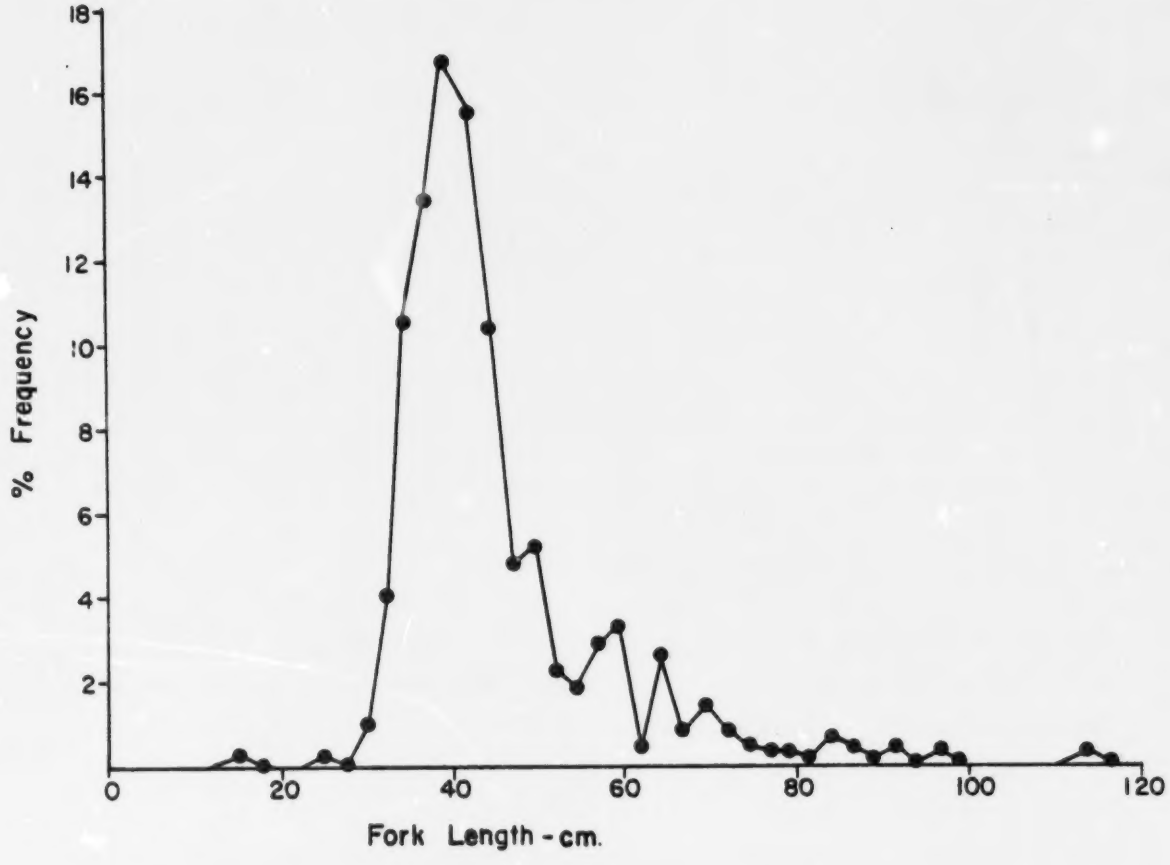


FIGURE 5-3: Length Frequency Distribution of Sport Caught Chinook Salmon in Kitimat Arm, 1980. Based on 707 Catches of Single Fish. The Minimum Size Restriction was 12 inches.

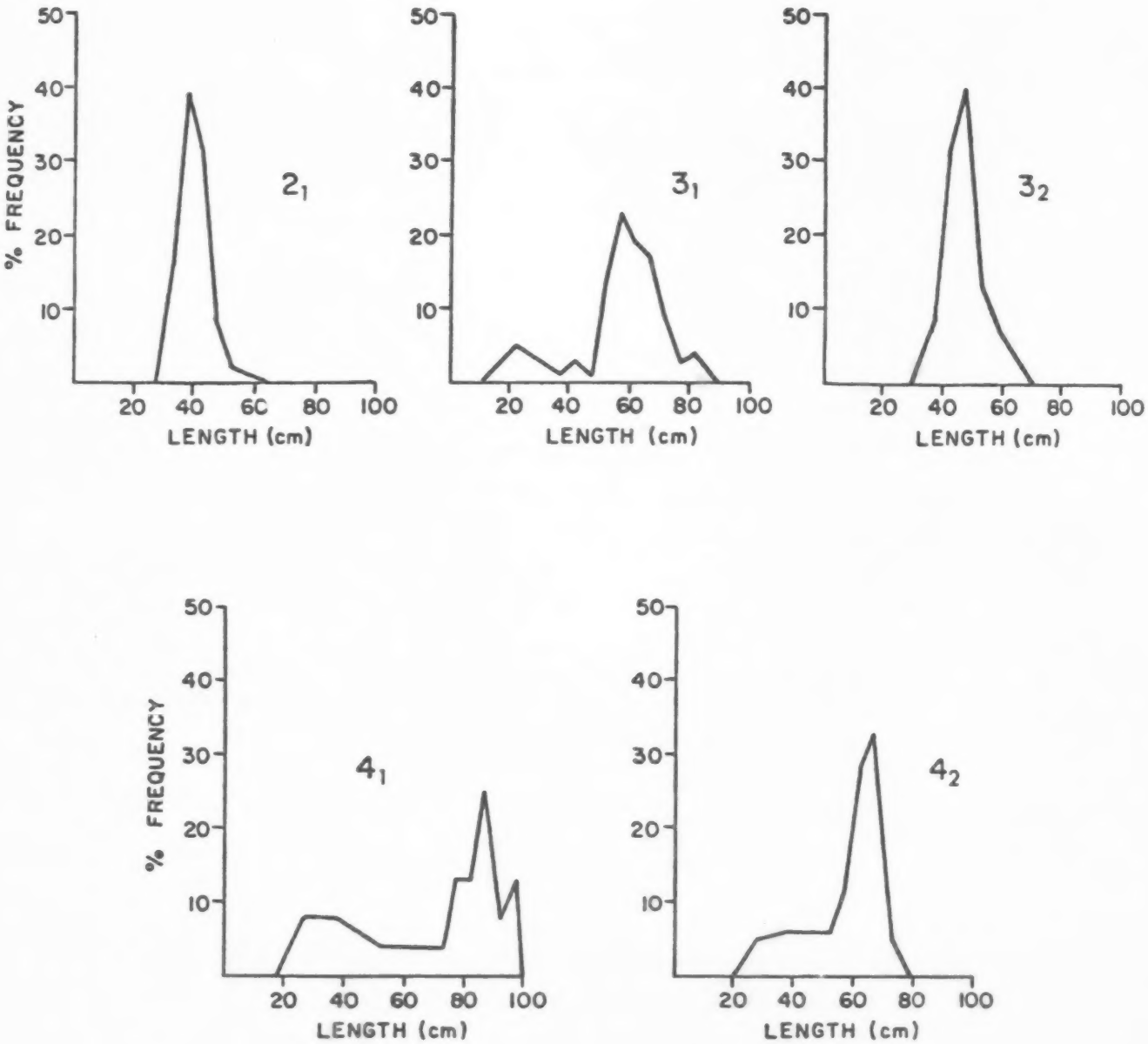


FIGURE 5-4: Length Frequency Distribution for 5 Age Classes of Chinook Salmon.

The results of the scale reading of 1980 creel census catches is shown below as a percent of the monthly catch.

TABLE 5-12: Monthly Percent Composition of Sport Catches by Age Class.

Scale Age	May	June	July	August	September	Seasonal Means
2_1	57.9	56.8	76.2	76.7	76.0	65.3
3_1	18.4	17.3	11.9	11.0	10.3	15.3
3_2	10.3	13.5	5.9	11.0	6.9	9.9
4_1	4.3	10.0	3.6	1.3	3.4	4.6
4_2	7.5	2.4	1.2	-	3.4	4.0
4_3	-	-	1.2	-	-	0.2
5_2	1.6	-	-	-	-	0.7

To provide a basis for comparison, Argue et al., (1977) investigated the age composition of commercial troll caught salmon in Georgia Strait in 1967, with the results shown in Table 5-13. (Note that his 'ocean age' refers to the number of saltwater annuli. Thus a 3_1 fish has an ocean age of 2.)

TABLE 5-13: Monthly Percent Composition of Georgia Strait Commercial Troll Catches by Age Class (Argue, et. al., 1977).

	% of Monthly Catch					
Ocean Age	May	June	July	August	% of 12 Month Catch	Modal Fork Length (inches)
2	1	4	26	27	8.6	19.6
3	85	84	69	68	80.7	24.4
4	13	12	5	3	10.4	32.4
5	-	-	-	-	0.3	-

This commercial troll fishery operated with a minimum weight limit of 2.5 lbs dressed.

Although comparable data are not available from the 1980 commercial fishery, the coded-wire tagging synopsis data provide some insight into the age classes currently being harvested in the northern and central commercial fishery. The following data (Thomas, 1981) consist of counts of coded-wire tagged chinook in a small subsample of the Northern and Central commercial catches. It is offered with the caution that the numbers observed reflect the age classes and stocks of fish that were tagged, and not the whole chinook population; i.e. they should not be interpreted as the proportional composition of the catch.

TABLE 5-14: Counts of CWT Chinook in a Subsample of the Commercial Fishery, 1980 (from Thomas, 1981).

	Chinook Brood Year			
	1975	1976	1977	1978
A. Northern & Central Troll Fishery				
July	9	25	21	1
August	2	16	27	1
September	0	5	11	0
B. Northern & Central Net Fishery				
July	4	9	19	21
August	0	10	11	16
September	0	0	4	8

It should be noted that the 1980 size restrictions on the commercial fishery were: Northern & Central Troll, minimum length of 66 cm (26 inches); Northern and Central Net fisheries, minimum weight of 3 lbs. round or 2.5 lbs. dressed.

5.6.3 Catches of Under-size Fish

The incidental catch of under-size fish is a matter of great concern to the fishermen in this area. The ratio of legal size chinook to under-size salmon (the

latter, not usually identified, may have been chinook or coho) caught by different baits is presented below (creel census data):

TABLE 5-15: Ratios of Catches of Legal Size Chinook to Undersize Fish by Baits used in the Sport Fishery (creel census data).

	Legal Size Chinook	:	Under-Size Salmon	Catch Ratio
Herring strip	1867	:	1554	1.20:1
Spin-n-Glo	5	:	3	1.67:1
Hoochies	336	:	307	1.09:1
Spoons	299	:	284	1.05:1
Needlefish	92	:	96	0.96:1
Combination	32	:	49	0.65:1
Whole Herring	45	:	34	1.32:1
Other	3	:	1	3.00:1
Overall (all catches)				1.17:1

The overall ratio of 1.17:1 for 1980 contrasts with a ratio of 1514:7899 = 5.22:1 for chinook in 1978 (Masse, 1980). Also note that the highest ratio (for Spin-n-Glo) observed in 1980 is based on a very small sample that consisted of catches of mature spawners approaching the Kildala River.

The overall ratio of 1.17:1 is biased low because the catch of other legal size salmon species has not been included. Adding the other salmon noted in creel census data, the overall ratio of legal size salmon to under-size salmon becomes 1.41:1.

The high frequency of hooking undersize fish has important implications for the fishery. Parker & Black (1959) found the mortality rate of under-size chinook in the commercial troll fishery to be 71%. Sport fishermen in general probably inflict less damage to undersize fish because of their more immediate response to having something on their lines, and their closeness to the water. However, even given a mortality rate of only 50% for these "shakers", the overall exploitation rate on the chinook population would be increased by approximately 43%.

6.0 EXPLOITATION RATES

6.1 Sport Fishery Exploitation

The 1980 sport fishery caught an estimated 6.6 thousand chinook salmon and hooked an estimated 6.0 thousand under-size fish. Mortality of under-size fish is estimated to contribute an additional 43% to the total mortality (see Section 5.6.3), giving a figure of 9.6 thousand as the total mortality due to sport fishing.

If the Petersen population estimate for 55 thousand is accepted, the average exploitation rate is 0.17 for the 5 month season.

This estimate of average exploitation rate does not take into consideration the likelihood that the population was much greater in March, April and May. This larger population experienced a very low level of fishing effort prior to June. On the other hand, the reduced population remaining in the study area in August and early September was exposed to relatively intense fishing effort and probably had a higher exploitation rate.

Scale data show that the 2_1 age class constitutes the major age class in the catch during all months and contributed more than 76% of the catch during the peak fishing months of July and August.

6.2 Commercial Fishery Exploitation

As mentioned in Section 4.2.3, there were 45 Kitimat code CWT fish caught in the commercial fishery in 1980. When expanded by the coverage of the landed catch and proportion tagged, the estimates of catches from these marked fish are as shown in Table 6-1. These recaptures come from initial releases as follows:

Stock	Brood Year	Released In	Tagged Smolts	Total Smolts
Kitimat (wild)	1976	1978	1,578	(not known)
Kitimat hatchery	1977	1978	75,496	75,996
Kitimat hatchery	1978	1979	73,436	151,771

TABLE 6-1: 1980 Commercial Catch Estimates for Kitimat CWT Chinook Stocks (numbers of fish, based on CWT recoveries expanded by the proportion of catch examined for tags and the ratio of tagged/untagged smolts released)).

	1976 Wild	1977 Hatchery	1978 Hatchery
Statistical Areas 1-5			
Gillnet		8.0	-
Seine		-	16.0
Mixed Net		4.0	16.0
Total Net		12.0	32.0
Troll		40.9	
TOTAL	0	52.9	32.0
Statistical Area 6			
Gillnet		-	
Seine		6.4	77.4
Mixed Net		3.2	45.2
Total Net		9.6	122.6
Troll		10.7	
TOTAL		20.3	122.6
Alaska			
All areas - Troll Only	6.6	59.4	39.6

The exploitation rates cannot be calculated directly because the population sizes from which these tags are taken are not known.

For the 1978 hatchery stocks and the Area 6 commercial fishery, one can make an approximation as follows: the population of the study area was 3% adipose-clipped, and 85% of these CWT tags were from the Kitimat 1978 stocks, so (as in Section 4.3.1) the number of 1978 Kitimat hatchery fish in the study area can be estimated at 2,800 fish in late June. If one assumes that the entire Area 6 commercial net catch estimate of 122.6 Kitimat 1978 fish came from the population that was in the study area in late June, the exploitation rate on the tagged population is 0.044. If this rate is applied to all 2_1 and 3_2 fish in the

study area, the contribution to the commercial catch in Area 6 would be 55,000 x 0.044 = 2,420 fish. The Area 6 net catch of jack springs ("jacks" in this case being the smallest size class and not an indication of sexual maturity) in 1980 was 7,397 fish. Therefore, as a rough estimate, the Kitimat Arm rearing population of 2_1 and 3_2 fish contributes approximately one-third of the net catch of jack springs in Area 6. (However, note that the majority of this population was not of local origin.)

Floy tag data show only 12 recaptures in the 1980 net fishery in Area 6, and 2 in the Area 6 troll catch. This yields a much lower catch estimate of (55,000/1,437) x 14 = 433 fish. The discrepancy between these two figures may indicate behavior differences between CWT and Floy tagged fish.

It is not possible to calculate exploitation on the stocks using the study area in their second ocean year because there is no reliable estimate of the population size. A high proportion of the commercial catches of the 1977 tag code was taken in the Northern Troll fishery, with additional catches being taken in the Alaska troll fishery. (See Section 4.3.2 for additional discussion of the fate of 1977 stocks.)

Newly available data from the 1981 commercial fishery show an increase in the Alaskan harvest of Kitimat tag code fish, especially of the 1977 brood year stocks. This trend should be watched carefully in 1982 as the larger cohort of 1978 brood fish are harvested in Alaska.

Although it is not possible to calculate exploitation rates from the available data, it is interesting to note that the 1977 brood year tags experienced almost equal catches in Canadian and Alaskan fisheries in 1980, and that Alaskans caught approximately 3 times as many 1977 CWT fish as the Canadian fleet in 1981. Alaskan data do not include returns from the commercial net and sport fleets, which presumably would increase estimates of Alaskan interceptions. It appears likely that more than half of the chinook produced at Kitimat will be caught in Alaska.

TABLE 6-2: 1981 Commercial Catch Estimates for Kitimat CWT Chinook Stocks (numbers of fish expanded from CWT data as in Table 6-1).

	1976 Wild	1977 Hatchery	1978 Hatchery	1979 Hatchery
Statistical Areas 1-5				
Troll	5.1	45.8	61.2	0
Net	0	12.0	40.0	22.0
TOTAL	5.1	57.8	101.2	22.0
Statistical Areas 6-12				
Troll	0	36.0	0	4.9
Net	0	13.5	63.0	0
TOTAL	0	49.5	63.0	4.9
Alaska				
Troll Only	0	297.0	158.4	0

7.0 MANAGABILITY CONSIDERATIONS

The chinook population which once appeared to be a practically unlimited resource of the Kitimat area is now showing most of the signs of severe distress. The drop in catch rate between 1978 and 1980 plus the shift to a lower age-class would, for most fisheries, signal a risk of imminent extinction and would warrant drastic management measures. It is interesting to examine some of the factors contributing to the disequilibrium evident in 1980 and what they signify for the future. Three common management tools - size limits, catch limits and enhancement - will then be examined.

7.1 Population Fluctuation Factors

Several factors bear analysis in examining the "small fish fishery" of Kitimat Arm. These are 1) sharply reduced natural spawning in the Kitimat River, 2) increasing sport harvest rates on 2-and 3-year olds during the 1970's, and 3) the fate of pilot hatchery fish released as 5-month old smolts. Data on these factors, provided by DFO are presented below.

	Chinook Spawning Escapement Area 6 (thousands)	Hatchery Releases of 5-Month Smolts	Salt Water Sport Catches	Commercial Chinook Catch* Area 6
1970	13.4	-	925	37,582
1971	22.6	-	983	34,737
1972	13.3	-	1,317	66,528
1973	13.3	-	2,108	27,496
1974	11.8	-	1,583	39,476
1975	5.2	-	2,452	32,189
1976	6.9	-		19,191
1977	3.8	-		17,528
1978	7.4	75,996	9,413	37,910
1979	no data	151,771		28,505
1980	no data	39,199	6,600	-

* These figures are from the net and troll fisheries operating in Area 6 on mixed stocks from many areas.

The stock composition in 1980 revealed that a majority of the fish present were 2-year olds originating at distant Canadian hatcheries. However, the records for 1978 and earlier indicate that 3-and 4-year olds used to predominate in the population. The low abundance of 3-and 4-year old fish in the 1980 sport fishery may be due to depleted natural spawning stocks in 1976 and 1977, but only if the local wild fish are more inclined to rear locally than hatchery fish from the same stocks. Clearly, hatchery production at Kitimat has not contributed significantly to the population of locally rearing juveniles, nor will it in future if 98% or more of the smolts released emigrate before reaching legal size. The increased harvest by the sport fishery appears to be a minor factor in comparison.

7.2 A 'Small Fish Fishery' - The Effect of the Size Limit

The preponderence of 2_1 age fish in the 1980 sport catch appears to be due more to the absence of 3-and 4-year olds than to attempts by the fishermen to harvest small fish. Figure 3-1 clearly shows some successful selection of larger fish by sport fishermen.

The length frequency distribution of seine-caught fish (Figure 3-1) showed only a small fraction of the population in lengths less than 30 cm (12 inches), but fishermen reported hooking undersize fish almost as frequently as legal size fish. This may reflect a lower catchability of the smaller fish to seine gear despite the herring bunt used. It is not possible to determine from the data available whether the component of the population smaller than 30 cm is under-represented in the seine catches or whether they are relatively more catchable to sport fishing gear and therefore have a disproportionately high frequency of hooking.

The catch rate of under-size fish is much higher in 1980 than observed in 1978, although this may be an artifact of the method of data collection in 1978. In any case, the ratio of legal size (greater than 30 cm) chinook to under-size fish observed in 1980 was 1.17:1.0, and it can be estimated that the mortality due to hooking of these smaller fish contributed an additional 43% to the mortality due to fishing. (See Section 5.6.3 for a fuller explanation of these figures.) Thus, to

the extent that the sport exploitation rate on the chinook population is a problem, it must be recognized that the deaths of hooked undersize fish account for approximately one-third of this exploitation.

The change in minimum legal size from 12" to 18" in 1981 decreased the landed catch drastically, and undoubtedly reduced the level of fishing effort to some extent (Jim Thomas, pers. comm.). However, the incidence of hooking undersize fish probably increased proportionately. In 1980, the ratio of 3-year old (3_1 +) to 2-year old (2_1 and 3_2) was approximately 3:1, and a hooking rate of 1.17 : 1.0 was observed. In 1981, if only 3-year old size fish were landed, the hooking ratio (based on the same stock composition) can be roughly estimated at 3.5 : 1. If half of the hooked undersize fish die, the mortality due to fishing may not have decreased substantially despite the reduction in landed catch.

Parker (1960) states that since chinook growth rate correlates with size (i.e.,they are gaining weight most rapidly at the largest sizes), they do not obtain critical size prior to maturity and therefore the "yield cannot be increased by a minimum size regulation."

In Puget Sound, it was found (Don Anderson, personnal communication) that dropping the size limit promoted a "small fish fishery." However, the Kitimat sport fishery is already a "small fish fishery," and the relative absence of 3-and-4 year old fish suggests that there is really no other option to the harvesting of 2-year olds. Since the 2-year olds taken in the sport fishery are not of local origin, it is not likely that this harvest can have a negative effect on local stocks.

If the size limit restriction was removed and fishermen required to keep all the fish hooked (given the same effort and catch limits), the mortality due to fishing in the Kitimat Arm area would be reduced by approximately one-third. Of equal importance is the fact that approximately half of this reduction would accrue to the larger fish, which are the more productive component of the population.

7.3 Good Fishermen versus Poor Fishermen - The Effect of the Catch Limit

Since over-harvesting of chinook stocks throughout the B.C. coast has necessitated a change in the daily limit from 4 in 1980 to 2 in 1981, it is interesting to look at the 1980 creel census data to determine what effect this change would have on the harvest in Kitimat Arm separate from the change in minimum size. Figure 7-1 shows the sport effort and chinook catch divided by the catch per fisherman.

(Catches of other salmon were insignificant in May and June, contributed an additional 22% in July, 60% in August and 50% in September (Section 5.2). It is not known how these catches would distribute between the different creel sizes. Evaluating the data on the basis of chinook catches only provides the most conservative evaluation of changes in catch limit.)

The creel census data were divided to compare the number of fish caught as first and second fish fish (i.e.,the first two from each creel) with those caught as third or fourth fish.

	May	June	July	Aug.	Sept.	Mean
% 1st & 2nd fish	76.3	80.2	82.9	87.5	91.0	80.0
% 3rd & 4th fish	23.7	19.8	17.1	12.5	9.0	20.0

If the estimated total catch were reduced by the proportion attributable to 3rd and 4th fish, the reduced estimated total catch would be 6,600 x 0.80 = 5,280. Since good fishermen often donate extra fish to less fortunate companions, the reduction might in fact be less than calculated above.

The reduction in catch limit from 4 to 2 provides very little reduction in exploitation rate: from 0.17 to 0.14. Its major impact is probably felt as a

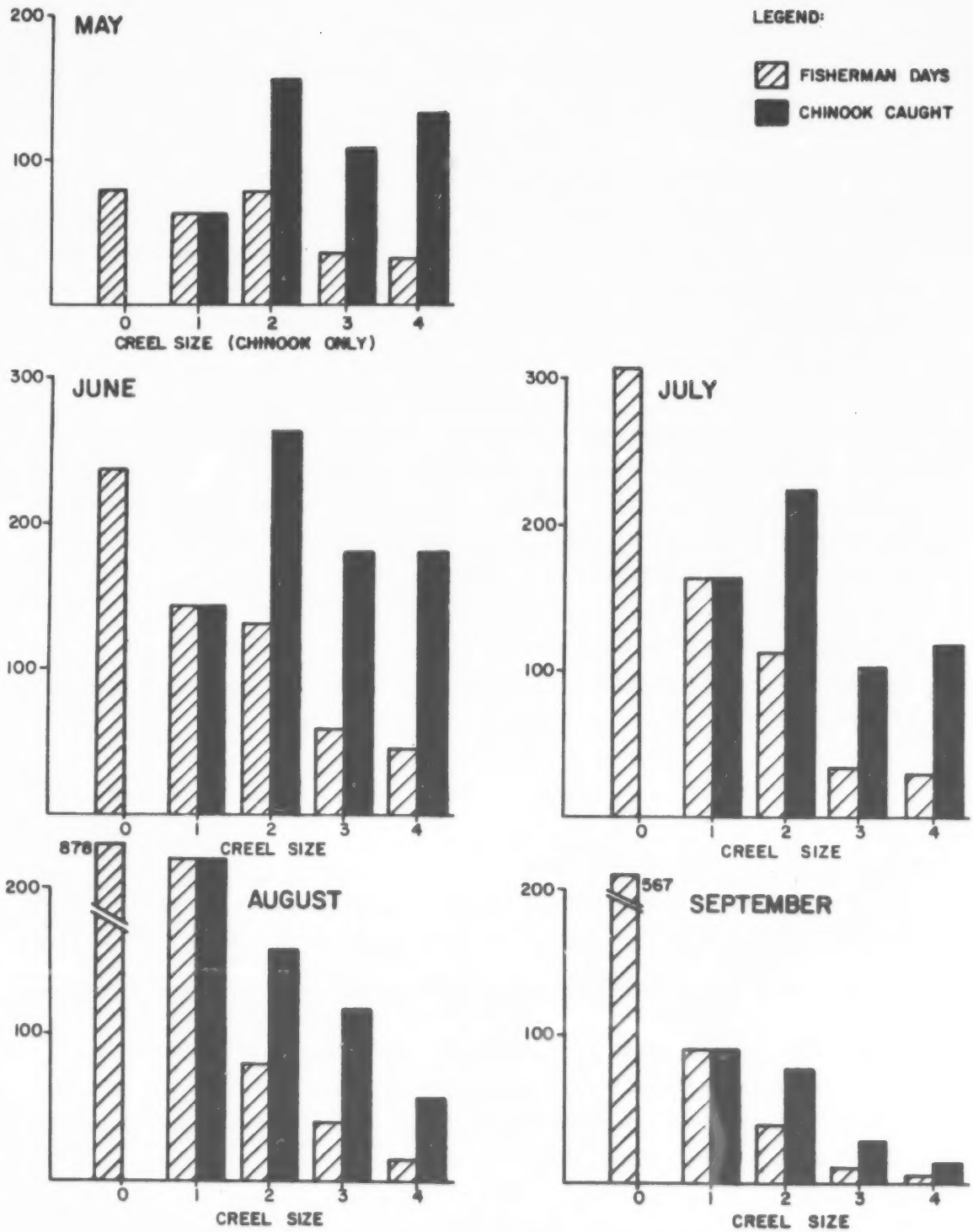


FIGURE 7-1: Sport effort and catch divided by creels (catches per fisherman) of 0 to 4 fish per day, by month.

reduction in the attractiveness of Kitimat to non-local fishermen. In 1980, 30% of the fishermen were from outside the local area. Although figures are not available for 1981, at least one of the charter operations ceased business and another reported many cancelled bookings (A. Sestrap and H. Smeets, pers. comm.). Thus, the change in catch limit may have reduced the economic benefit from the local sport fishery to a much greater extent than it protected chinook salmon.

7.4 Conclusions

The following points appear to be the most germaine concerning management of the local sport fishery:

- The enjoyment of recreational boating is more important than size or number of salmon caught, but it is clearly enhanced by the anticipation of good fishing.

- The chinook harvested locally are not primarily of local origin.

- The Kitimat hatchery does not appear likely to increase the number of locally rearing 2-and 3-year old chinook.

- The current sport harvest does not appear to be excessive (17%), and the migration of fish away from the headwaters during the peak of sport fishing effort provides a large measure of protection.

Considering the above, it seems that there is little to lose and much to gain in allowing increased sport fishing in Kitimat Arm with a 12" size limit. Efforts should be made to study the local wild stocks to determine their catchability in this fishery and ensure their protection. The possibility of different behavior of hatchery raised fish, making them less available to local sport fishermen and exposing them to heavy harvests in Alaska, is a problem that should be investigated in planning hatchery operations.

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